11 APR 1956

The Journal of the Indian Botanical Society

Vol. XXXV 1956 No. 1

THE BOTANICAL EXPLORATION OF INDIA*

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Introduction

During the past year, whilst holding the post of Chief Botanist, Botanical Survey of India, it became my duty to find out the extent of botanical exploration in our country. For this purpose I made use of the extensive library facilities of the B.S.I. At the outset, however, I came across a serious difficulty in my quest; several of our Indian universities for some years have been doing excellent work in this line, the results of which have appeared in the various university journals of India. But to my great disappointment, I was unable to consult all such journals, for the simple reason that there is no university in India where the journals of *all* our Indian universities may be examined.

This limited circulation of our university journals raises a serious question on a matter of importance: it is about the validity of publication of some of the new genera or species of plants described therein; in view of the limited distribution of such journals, it is questionable if publication may be considered *effective* in the sense of the *International Code of Botanical Nomenclature*. In Recommendation No. 39 of the present Code it is stated: "Botanists and others are urged scrupulously to avoid the publication of new species, names or combinations in ephemeral publications such as popular periodicals, *in any publication unlikely to reach the general botanical public*, or in those produced by such methods that their permanence is unlikely." (Italics mine own.)

To obviate such difficulties, I would strongly recommend that all universities in India would enter into an exchange of their Journals or Memoirs among themselves; further that copies of all journals be sent to the Botanical Survey of India, to the Directors of INSDOC, of UNESCO in India, and at least to the editor of *Biological Abstracts* and to some of the great herbaria of the world. Such abstracting or indexing organisations would see to it that the botanical public was kept informed of the progress of Botany in India.

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* Presidential Address delivered at the 35th Annual Meeting of the Indian Botanical Society held at Agra in January 1956.

In my quest for knowledge about the botanical exploration of India, I have examined some of the best herbaria in India and abroad, and have consulted most of our provincial or local floras. The impressions gathered from this examination are set forward in the following pages.

Some parts of India have been more or less intensively explored in the past by numerous botanists; this is the case with some of the more popular hill stations of India. During the summer vacation such hill stations have been explored, at times intensively; but little or no work has been done at other times of the year; the monsoon and the cold months of the year have often been left out completely.

What has been Done in the Botanical Exploration of India

It had been my plan when preparing these notes to give a comprehensive list of the publications on the botanical exploration of the various botanical provinces of India; but finally I decided to leave this part out of my discussion, first because it would have made this paper much too long, and secondly because most of the relevant data have been given in a paper on *Progress of Botany in India*, which is in the hands of the editors ready for the press. In this paper I shall confine myself to some general remarks.

A careful examination of the literature on the subject shows that even though most parts of India have been explored at different times from the beginning of the last century, and that, as Hooker and Thomson remark in their *Flora Indica*, p. 128, "there are not many more phanerogamic plants to reward the labours of future investigators", yet it is plain that most parts of India are in need of a very thorough exploration.

It is clear that very few places have been explored methodically in the past; by this I mean that very few areas have been so explored that we may say that we know the complete flora of the area and the various changes that occur in the course of the year's seasons. Cooke in the Flora laments that a particular plant "unfortunately flowers in July, at which time the hill-sides are streaming with water, rendering plant-collecting a task of no ordinary difficulty". Over a century previously Sir William Jones had remarked: "Before I was acquainted with the method pursued by Van Rheede, necessity had obliged me to follow a similar plan on a smaller scale; and as this mode of studying botany, in a country and climate by no means favourable to botanical excursions, may be adopted.... (*Asiat. Res.*, **4**: 240, 1798, London edit.). The method of van Rheede was to send collectors into the field, and to prepare diagrams and descriptions of such plants as had been brought to him by his collectors. Such methods may have been useful when our knowledge of the botany of India was in its infancy, but they are totally inadequate at present. The "unfortunate" circumstance of the heavy rainfall during several months of the year should not deter botanists from going into the field; for it is at such times that some very interesting medicinal plants come into their own in many parts of the country. Any place, then, that is taken up for botanical exploration should be visited regularly in every type of weather, and the changes in the vegetation of the place noted down.

Further it is not sufficient to send collectors into the field; unless they are very well trained, they will not notice many details that may be of great interest for posterity. In my own experience, on a certain occasion I sent my collectors to a part of the Western Ghats that I thought was rather rich in its flora; they collected exactly four specimens, the only ones seen in flower by the collectors; the following day I went there personally and collected over sixty specimens, most of which had not been considered worth collecting by my assistants, or had not been seen by them.

Khandala on the Western Ghats of India is a place that for over a century has been visited by Bombay botanists beginning with John Graham. When, however, I started my work on the flora of the district, I was much impressed by the absence of references to the monsoon flora of the district; plenty of plants had been collected during October and May, the two months when the station becomes a summer resort, but the heavy rains seemed to have kept botanists away from the area. In other places, such as Mahabaleshwar, in addition to heavy rains there is great difficulty on account of leeches during the rains. The monsoon flora of such well-known spots is practically unknown.

When discussing this point with Dr. N. L. Bor, the Assistant Director, Royal Botanic Gardens, Kew, he wrote to me: "*Sapria himalayana* was collected by Griffith in the Mishmi Hills in 1833, and was never seen again until I collected it in the Aka Hills in 1933 in August. It is *extremely* common at that time in the leech infested jungles in the hills of both sides of the Brahmaputra. Again the grass genus *Cyathopus* collected by Hooker about 1848, remained a curiosity until my Sikkimese collector brought it in 1945. He collected it in June and July."

These remarks of Dr. Bor bring to my mind having noticed in Cooke's *Flora of the Presidency of Bombay* that a fair number of plants are therein classed as *rare* or *very rare*; in point of fact, however, many such plants are rather common and abundant during the months of July to September, the monsoon months for Western India. Due to the unpleasant weather of the time, such plants have seldom been collected and are scarcely represented in our herbaria. To mention but one example, the plant that goes under the name of *Dolichos bracteatus* Baker is said to be so rare that Kew Herbarium possesses but a few scraps of the same. On the other hand in my fieldwork I have found masses of the plant in most of the higher hills of Bombay State; the plant comes into flower in the middle of the monsoon, its fruits are gathered by local people as an article of food, so that when the fair weather of October comes, there is nothing left for the botanist who depends on fair weather for his collections.

Even today there are many spots in India, where practically no botanical exploration has been done. The reason may be the distance from any university centre, or political restrictions (as in the case of Bhutan), or the various inconveniences of the place such as heat or cold or mosquitoes, leeches, etc. It is rather surprising that such important areas as Rajputana, Saurashtra, Cutch, many spots in central India and large tracts of the Himalayas, have not attracted the atten-

tion of Indian botanists. Perhaps they have fallen into the common mistake of considering such places as not deserving of exploration because they do not possess evergreen or at any rate conspicuous forests.

This attitude is to be lamented; the flora of the arid or semi-arid regions of India is of great interest; many of the plants are of considerable medicinal importance, as shown by the use made of them by the local vaidyas; further the study of such areas becomes rather easier precisely because of the sparse vegetation of the same. This applies also to other and better or more favourable parts of the country during the dry months of the year; we need precise information on the arid or semi-arid regions of India and on the vegetation of the dry season of better areas.

Even the better explored parts of India can do with some more systematic study; it is desirable to have all the year observations, notes on the density of the vegetation or of a particular plant in a given district. In practice it is not a wise policy to separate systematic botany from ecological studies; if India is to make good use of the raw materials from the plant world, it is necessary to know the life-cycle of the plants in question, their relative abundance, and as far as possible the exact spots where plants are to be found, or at least the sort of association, the type of soil, etc., where a given plant may be found. It is clear, therefore, that for proper botanical collection it is the botanist himself that should go into the field, and not trust to collectors alone.

Suggestions for our Universities

I hope that it will not be considered presumptuous on my part that I dare offer suggestions to our universities on the subject of what may be their contribution to the complete botanical exploration of India. The ideas herein contained have been evolved in many years of work in the field, and after studying, as Chief Botanist, the needs of our country.

Most of our universities like many of the best universities of the world, are handicapped by the short funds at their disposal for research. For this reason it is important that whatever funds be made available for botanical exploration be employed wholly for this purpose. It is then suggested that as far as possible universities concentrate their botanical researches in their own districts and leave far away exploration to the Botanical Survey of India; in this way funds will be spent in real botanical work of great value to the country, and botanists will be free from the accusation that their aim is to have grand scale picnics at the Government's expense.

The area to be selected for botanical exploration should not be too big; it is surprising, once the work has started in earnest, how much work can be done in a relatively small area. I would recommend that an area about 10 miles in diameter round the university be taken as first object of exploration; this area may appear too small, but in fact it may even be too large for intensive exploration. Let our young botanists be trained in this restricted area until its flora is

completely known; the area may then be expanded by a few miles more, and thus gradually the whole of India may be finally covered by the research workers of the various universities of the country.

Exploration must be intensive; there must not be any season left out on account of the inclemency of the weather. It is precisely in these adverse seasons when the more important and interesting plants come into flower or fruit. Once the area has been well and carefully selected and properly demarcated, the whole of it should be explored at least once every month, or even oftener if possible. No new plant may be recorded in this intensive exploration, but the phenology of each plant, its complete life-cycle, its relative abundance and distribution can be studied.

In my opinion it is a great mistake that is often made when field botanists do not collect or at least record in their field books a plant, because it may have been seen often in the field; as a result many of our Indian herbaria show very few specimens of the commoner plants, whilst they may contain large numbers of somewhat rarer specimens. Students of the herbarium alone can easily obtain a distorted idea of the vegetation of any area from the collections in such herbaria.

The Revision of the Flora of India

Every botanist, who has had to handle Hooker's *Flora of British India*, needs no argument to convince him of the crying need for the revision of the book. Large numbers of new plants have been described since the book was published; many changes have been introduced into the nomenclature of plants; the identity of some important plants has been carefully studied and found to differ from what is written in Hooker's Flora. The need for a complete modern revision of the type of, say, *Flora Malesiana*, with plenty of illustrations and correct identifications and nomenclature of all our plants, is agreed upon by most botanists.

When speaking of Systematic Botany I do not mean to confine myself to the Angiosperms; we need national and provincial floras of the Algæ, Lichens, Bryophytes, etc. of the country; of late such plants have assumed great economic importance, and if our students wish to help in the development of the natural resources of India, they need proper floras to cover such aspects of our vegetation. It is to be regretted that sufficient work has not been done on many of these lower groups; but if at least we had proper floras to give in concise form whatever has been known about such plants more students might feel inclined to go for them in the field.

In the preparation of all these books, *i.e.*, the revision of the *Flora of India*, and the writing up of books on lower groups of plants, one serious question arises as to the suitability of the times for such books. The time seems propitious for the work to be started at once; the revival of the Botanical Survey of India, and the promise that the Records of the same will soon be revived, guarantees that the work will be carefully and properly done, and that facilities for publication will be given

to every worker. Without wishing, however, to dampen the ardour of our botanists, it is necessary to point out the need for more intensive collection of plants from all over the present territories of India; many places are still completely left alone by botanists; many places have been explored in a far from methodical manner in the past, our monsoon plants are practically untouched. Nevertheless, it should be possible to start at once with the revision at least in a provisional manner; whatever we may include in the new revision will be of great help to field botanists all over the country; this is important at present when most of our provincial floras are out of date and out of print. The classical books of Wight, Beddome, etc. are completely unobtainable, and even when it is possible to consult them in some of the larger libraries, they are so brittle that their pages fall in pieces at the least touch; a modern illustrated flora on Angiosperms, Algæ, etc. would certainly answer the needs of the country.

There is, however, another and greater difficulty than merely finance or the time required for a work of this magnitude; in the recent past plant taxonomy has been very much neglected in most of our universities, and in consequence we have but a few systematists in our country. We have to train our personnel before the task is undertaken, and this may impose a delay of three to four years at the least.

In the study of plant systematics many of our students suffer from a great handicap; this is that such students have neglected the study of the more common European languages, in which the majority of the papers on systematic botany are written; French and German should be studied by at least every research worker in the subject; Latin, as the international language of Botany, should be so mastered that easy passages may be translated even without the aid of a dictionary; further, in view of the extensive literature in Russian, this language should also be studied. And above all, every systematist should make himself familiar with the provisions of the *International Code of Botanical Nomenclature*, without which it is next to impossible to do any serious work on the subject.

Conclusion

By way of conclusion I beg to be allowed to repeat some of the more important recommendations made in this paper:—

1. It is of little use reprinting Hooker's *Flora of British India* in the present form; the book has to be revised, the identity of many of the plants checked and their distribution and relative abundance properly determined.

2. In general it is desirable that greater attention be paid in our universities to Systematic Botany; and this includes not only the flowering plants but also lower groups such as Algæ, Lichens, Bryophytes, Mosses, etc.

It is only fitting that Independent India should be wholly responsible for the revision of its flora; we may obtain help from various specialists in other parts of the world, but the bulk of the work should be entrusted to Indians, who can best appreciate the needs of the country.

PRODUCTION AND SYSTEMIC TRANSLOCATION OF FUSARIC ACID IN *FUSARIUM* INFECTED COTTON PLANTS

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(Received for publication on October 17, 1955)

Introduction

Certain species of Fusaria are known to produce the phytotoxin fusaric acid (Yasue, 1949; Gäumann, Naef-Roth and Kobel, 1952). The *in vivo* detection of fusaric acid (Lakshminarayanan and Subramanian, 1955) and its translocation in *Fusarium vasinfectum* Atk. infected cotton plants is being reported in this paper.

Experimental

Detection of fusaric acid in vivo.—Bulk samples of 2–3 weeks old *F. vasinfectum* infected cotton plants as well as cut shoots of plants treated to solutions of pure fusaric acid were ground up with distilled water, centrifuged and the clear extract was concentrated *in vacuo* at room temperature. Chromatograms of the extracts were run (butanol, acetic acid, water solvent) in test-tubes (Rockland and Dunn, 1949), and the dried chromatograms were spread on bacterial seeded agar (Zähner, 1954) and R_f value of fusaric acid determined in the usual manner (Table I).

Table I

R_f value of fusaric acid

	Pure sample	Detected in cut shoots of cotton treated to pure fusaric acid	Detected in cotton plants infected with *F. vasinfectum*
R_f value ..	·89	·88	·87

The R_f value of the antibiotic obtained from cut shoots of cotton treated to pure fusaric acid (Plate I, Fig. 1) and *F. vasinfectum* infected plants (Plate I, Fig. 3) corresponded to the R_f value of pure fusaric acid (Plate I, Fig. 2), thereby indicating the presence of this toxin *in vivo* in infected cotton plants.

Quantitative estimation and systemic translocation.—The extract from 100 g. (fresh weight) of infected plants was concentrated to 5 ml. and employed neat and at 50, 10, 1, ·1 and ·01 per cent. levels for the

quantitative determination of fusaric acid by the modified agar-cup technique (Kalyanasundaram, 1955 *a*). No antibiotic activity was detected in the extract at 1, ·1 and ·01 concentrations, but the two higher concentrations and the neat extract produced marked inhibition zones (Plate I, Fig. 4); neat extract of healthy plants showed no antibiotic activity. Fusaric acid yield from the infected cotton plants is given in Table II.

TABLE II

Fusaric acid in cotton plants

Total No. infected plants	Fresh weight of the plants	Fusaric acid yield per plant
100	100 g.	17·28 μg.

The translocation of fusaric acid within the cotton plants was studied employing Pramer's technique for detection of antibiotics in plants (Pramer, 1953). Root, stem and leaf sections of *F. vasinfectum* infected and healthy plants were cut, crushed between sterile glass plates and plated on bacterial seeded agar. Clear inhibition zones were formed only around infected plant sections (Plate I, Figs. 10, 11 and 12) and not around healthy tissues (Plate I, Figs. 7, 8 and 9). The plant exudate of infected cotton, absorbed on discs of filter-paper, similarly showed antibiotic activity (Plate I, Fig. 5), whereas the exudate from healthy plants did not contain any antibiotic (Plate I, Fig. 6).

DISCUSSION

In recent years much work has been done on the production of antibiotics in soil (Grossbard, 1952; Jefferys, 1952; Wright, 1952) and their uptake by higher plants (Brian, Wright, Stubbs and Way, 1951; Pramer, 1953), but very little is known about the production of 'wilt' toxins in soil by plant pathogenic fungi. However, earlier work (Kalyanasundaram, 1955 *b*) showed that *Fusarium vasinfectum*, the cotton wilt pathogen, produced appreciable quantities of fusaric acid in sterilized and amended soil. The present work has shown that fusaric acid is produced *in vivo* in cotton plants infected with *F. vasinfectum*, the identity of the toxin having been established by the chromatographic bioassy method (Plate I, Figs. 1, 2 and 3). The detection of free fusaric acid in cut shoots of cotton treated to various concentrations of the toxin (Table I) and the antibiotic activity observed in leaf, stem and root sections of infected plants (Plate I, Figs. 10, 11 and 12) demonstrated the systemic presence of the toxin and its translocation within the cotton plants. Fusaric acid, therefore, resembles many of the other antibiotics which are known to be taken up and translocated by plants (*loc. cit.*) but unlike other antibiotics fusaric acid is toxic to plants at comparatively low concentrations (Gäumann, 1951).

Quantitative estimation of fusaric acid showed the amount present in a single infected cotton plant was 17·28 μg. The fact that smaller quantities of the toxin, present *in vivo*, is sufficient to produce typical disease reaction in cotton, compared to larger quantities of fusaric acid required to produce symptoms in cut shoots (30 mg. toxin/1 kg. fresh weight, Gäumann, 1951) shows that other factors present within the plants may be interacting in increasing the sensitivity of the cotton plant to the toxin *in vivo*. This seems to be in line with the earlier observation of Gäumann *et al.* (1952) who stated that the toxic potency of fusaric acid is dependent on the fresh weight of the plant, pH of the substrate, synergistic action of the plant constituents and its dissociation factors.

Scheffer and Walker (1953) and Dimond and Waggoner (1953) stated that lycomarasmine, another wilt toxin, being a lytic product could not be produced in a short period of 14 days within the tomato plants, although such plants infected with *F. lycopersici* wilted during this period. In the case of fusaric acid, however, the toxin could be detected in culture filtrate within 4 days of fungal growth (Kalyanasundaram, 1955 *c*) and is produced in cotton plants soon after infection; symptoms of fusaric acid toxicity were noticeable in 13 days old seedlings (Kalyanasundaram, 1954), and actually 17·28 μg. of fusaric acid were obtained per plant from 2–3 weeks old plants (Table II).

The evidence presented here further substantiates the toxin theory of wilting in fusariose wilts inasmuch as fusaric acid, an established wilt toxin, has been detected *in vivo* in infected cotton plants using chromatographic bio-assay. Further, it is possible that fusaric acid plays an important part in other fusariose diseases, such as wilt of tomato and foot rot of paddy, since this toxin is known to be produced by *F. lycopersici* and *Gibberella fujikuroi* (Gäumann *et al.*, 1952) the respective pathogens.

Summary

The present work reports the *in vivo* detection of fusaric acid in cotton plants infected with *Fusarium vasinfectum* Atk., using chromatographic bioassay technique. It was also possible to demonstrate the systemic translocation of free fusaric acid inside an infected plant. The quantity of fusaric acid inside an infected plant, 2-3 weeks old, was 17·28 μg. under the growing conditions now reported.

Acknowledgements

We thank Prof. T. S. Sadasivan for suggestions and help, Dr. C. V. Subramanian for criticism and Prof. Dr. E. Gäumann, Zurich, for the sample of fusaric acid.

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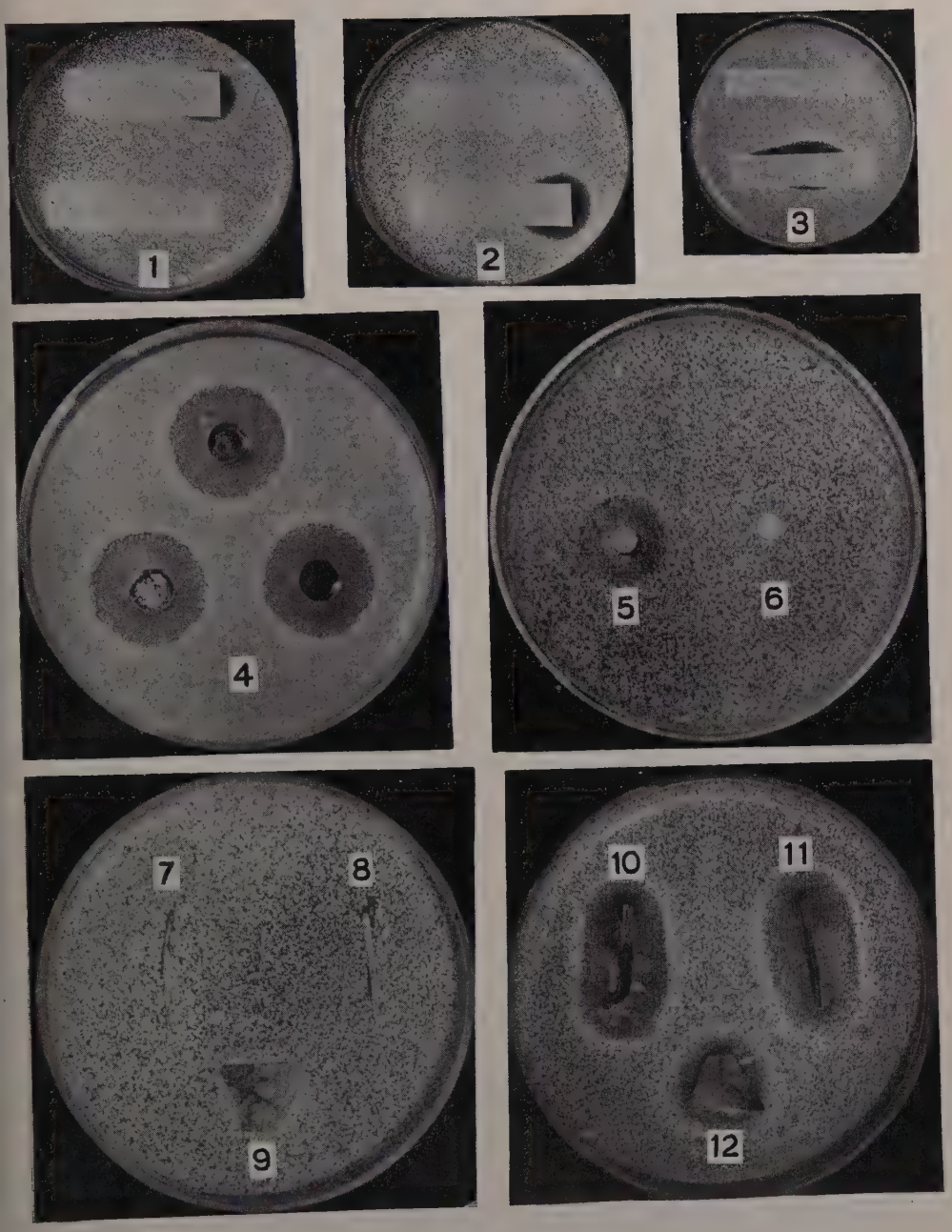
EXPLANATION OF PLATE

PLATE I. Quantitative and chromatographic bioassay of fusaric acid. Fig. 1, extract of cut shoots of cotton previously treated to pure fusaric acid; Fig. 2, pure fusaric acid; Fig. 3, extract of *F. vasinfectum* infected plants. Fig. 4, quantitative determination of the toxin in infected plants by the agar-cup technique. Discs of filter paper with exudates from infected (Fig. 5, note inhibition) and healthy (Fig. 6) plants. Root, stem and leaf of healthy (Figs. 7, 8 and 9) and infected plants (Figs. 10, 11, and 12) plated on bacterial seeded agar showing inhibition around the infected tissue.



R. Kalyanasundaram and C. S. Venkata Ram

STUDIES ON COLCHICINE INDUCED TETRAPLOIDS OF *CORCHORUS OLITORIUS* LINN. (JUTE)

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(Received for publication on August 26, 1955)

Introduction

The two cultivated species of *Corchorus* (Tiliaceæ), *C. capsularis* and *C. olitorius*, from which jute fibre of commerce is derived have each certain desirable characters. *C. capsularis* is comparatively more resistant to flood and drought but slightly more susceptible to diseases and pests; it gives the 'white' fibre of commerce which is slightly weaker. *C. olitorius* is tolerably resistant to diseases and pests, grows generally on high and medium land and produces the strong 'tossa' fibre of commerce with a slight tinge of dark red. A combination of the desirable characters of the two species in a single hybrid with ability to grow almost on all types of land, comparative immunity to diseases and pests and with strong white fibre would make an ideal jute plant. Thousands of straight crosses made between the diploids of the two species failed (Ghose and Patel, 1945) and it was felt that incompatibility might be overcome by crossing the two species in the tetraploid state.

Rao, Sanyal and Datta (1944–45) treated seeds of both the species and tips of vigorously growing young plants of *C. capsularis* with different concentrations of colchicine solution for different periods and obtained tetraploids in *C. capsularis* in the 0·1 per cent. concentration and 24 hours duration treatment, but failed to induce polyploidy in *C. olitorius*. The affected *capsularis* plants showed increase in the size of stomata, floral parts and fruits. The ultimate fibres showed greater length and breadth and wider lumen but the thickness of the cell-wall did not show much change. The fibre bundles were also larger in size and this was due to the increase in the breadth of the ultimate fibres, rather than their number. Bhaduri and Chakrovarti (1948) successfully obtained tetraploids of both the species by treating seeds and seedlings. They crossed the tetraploids and even expected a few fertile F_1 plants. The tetraploids showed giganticism of several morphological characters but the number of ultimate fibres did not increase though the total volume of fibre as compared to the diameter of the stem increased. Nakajima (1949) also treated seeds of *C. capsularis* and studied the tetraploids. However, studies on economically important characters like fibre yield, maturity, etc., have not been reported by any of the authors.

Studies were undertaken by the authors to evaluate the desirable characters, if any, of the tetraploids, especially of *C. olitorius*, and the

possibilities of utilising them in a programme of interspecific hybridization.

Materials and Methods

Seeds of both *C. capsularis* and *C. olitorius* were treated during 1948 and again during 1950. In 1948 only two tetraploid plants were obtained in *C. capsularis*, one in 24 hours—0·15 per cent. and the other in 18 hours—0·20 per cent. treatments but polyploidy was not induced in *C. olitorius*. The treatment was repeated in 1950 when tetraploids of both the species were obtained. Seeds of *C. capsularis*, variety D 154 and *C. olitorius*, variety Chinsurah Green (C.G.) were treated for 3, 6, 12, 18 and 24 hours with 0·0125, 0·025, 0·05, 0·10 and 0·15 per cent. water solutions of colchicine. Fifty well developed seeds were soaked directly in the solution and at the end of each treatment, washed in running water and sown in specially prepared plots. The germination was recorded at the end of a fortnight and plants exhibiting morphological abnormalities were selected at the end of a month from the date of sowing. Observations on the selected plants and controls were recorded at periodical intervals and single pods (fruits) were collected separately from all the selected plants for further studies. From the C_2 generation onwards the elites were maintained by propagating the plants from seeds collected from separate pods of each of the selected plants.

For cytological studies flower-buds were fixed in 1 : 3 acetic alcohol mixture and anthers were squashed in acetocarmine. For anatomical studies plants were collected at small-pod stage and were sectioned with a base sledge microtome. Ultimate fibres were studied after maceration with 5 per cent. chromatic acid. Seeds of whole plants were used for yield and correlation studies where adequate population was required but the stock material was always propagated by using seeds of single pods of selected plants.

Though studies have been made in both *C. capsularis* and *C. olitorius*, observations only on *C. olitorius* have been reported in the present paper. Observations on *C. capsularis* will be dealt with in a separate paper.

Observations

As stated earlier, 50 treated seeds of *C. olitorius*, variety Chinsurah Green, were sown in each treatment and germination was recorded after a fortnight; plants showing morphological abnormalities were selected after another fortnight. The table below gives the details.

In general, the germination of treated seeds decreased with increasing concentrations except in the 3 hours group. With increasing duration, however, germination perceptibly decreased only in the higher concentrations. As compared to the control, the viability of seeds, even in mild concentrations of solutions and shorter durations of treatment was severely affected and the proportion of plants showing morphological abnormalities roughly increased with increase in the concentrations of the alkaloid employed and the duration of the treatment used.

TABLE I

Number of seeds germinated and number of plants with morphological abnormalities in the C_1 generation

Duration of treatment (Hours)	Number of seeds germinated					
	3	6	12	18	24	Total
Concentrations						
0·0125	14	17	18 (2)	9 (3)	20 (3)	78 (8)
0·025	7	20	3 (1)	2 (2)	5 (4)	37 (7)
0·050	19	13 (1)	4 (2)	0	3 (3)	39 (6)
0·100	18	8 (1)	1 (1)	0	0	27 (2)
0·150	14	7	0	0	0	21
Total ..	72	65 (2)	26 (6)	11 (5)	28 (10)	202 (23)
Untreated (control) ..	45					

(Figures in brackets indicate the number of plants selected for morphological abnormalities.)

Of the 23 plants selected, one plant from the 0·025 per cent. concentration and 24 hours duration was sterile and another was destroyed by external agencies. During the C_1 generation the plants were weak in growth, possibly due to late sowing, and only 160 pods were collected from 21 plants and the seeds of each pod were counted and classified into healthy and unhealthy. Pods from 18 of the plants contained varying proportions of good and bad seeds and seeds from the rest were all healthy showing that they were unaffected by the treatment. The number of good seeds in the pods was variable but the selected plants recorded an average of 49 seeds in the pod against 157·58 of the pods of controls.

In the succeeding year, the seeds from each pod were sown separately in lines. Only pods from four of the 21 plants gave progenies that showed variations characteristic of tetraploids and the rest produced normal plants. One of these, 5095, was a pure tetraploid and in the other three, all the plants from the seeds of any single pod were of one type, either normal or tetraploid, but seeds from different pods of the same plant or even of the same branch produced both normal and tetraploid plants, showing that in these three the plant as a whole or even the branch was a mixoploid. The table below gives the details.

The $4n$ plants in the C_2 and later generations show giganticism characteristic of the tetraploids even from the cotyledonary stage. The cotyledons are larger and more succulent. The leaves are broad

TABLE II

Showing the behaviour of pods from C_1 selections giving tetraploid progenies

Concentration	Duration (Hours)	Selection number	Number of pods sown	Number of pods producing tetraploids
0·0125	24	5053	7	3
0·0250	18	5051	10	9
0·0500	12	5095	3	3
0·1000	6	5092	32	24

and coriaceous. The stomata are larger in size but are fewer in number. Though increase in the length of the leaves was not observed, definite increase in breadth was noticed, thus marking off the tetraploid leaves as broad (Pl. III, Figs. 1 and 2). The comparative size of the leaves is given below:—

	Length (mm.)	Breadth (mm.)	Length-Breadth ratio
4 *n*	191·34	101·82	1·88
2 *n*	191·04	83·80	2·28

(Average of 5 leaves per plant, 5 plants per plot, 6 plots of each.)

The younger leaves of the tetraploids are susceptible to 'scalding'. Portions of the leaf near the tip begin to wither and dry up and the disease spreads towards the petiole. As no pathogen responsible for this could be isolated, the disease appears to be physiological; it is, however, peculiar that diploids are immune to the disease.

In general, the tetraploids are more branched, the average number of branches per plant in the tetraploids being 11·7 and 6·2 in the diploid.

The cytology of the normal diploids has been worked out by Banerjee (1932) and Datta (1952) and some details of the cytology of tetraploids of *C. olitorius* have been given by Bhaduri and Chakravarti (1948). The P.M.C.s show occasional irregularities, both multi-

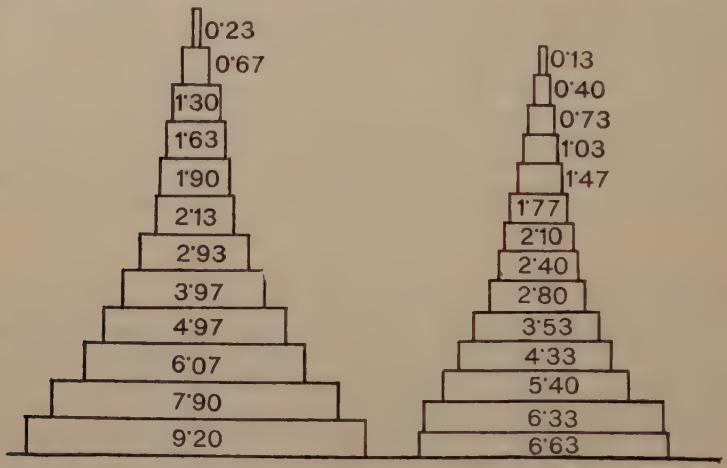
valents and univalents being formed in the first meiotic metaphase. One to two tetravalents, one of them a ring of 4, a trivalent and 1–5 univalents generally occur, the rest being present as bivalents (Pl. II, Figs. 1 and 3). The pairing is fairly regular and in anaphase I, 1–6 laggards often corresponding in number to the univalents, are noticed. However, all the laggards manage at the end to reach the poles. In certain of the cells, the spindle fails to be formed in the second division, the chromosomes are irregularly dispersed and restitution nuclei result (Pl. II, Fig. 2). Occasionally due to the complete failure of the second division diads are formed. In one instance a hexad was noticed (Pl. II, Fig. 4). This might possibly be the result of further division of two of the cells of the tetrad. In spite of these occasional irregularities, the pairing in the majority of the P.M.C.s is regular and the cells of the tetrad do not show much variation either in the number of chromosomes or in the size. The percentage of fertile pollen grains as shown by aceto-carmine test averages from 88–96 per cent. as against 92 per cent. of the diploids and confirms this.

Though the flowering in the $4n$ population begins at about the same time as that of the normal plants, the duration of the flowering period is prolonged by nearly a month after it has ceased in the normals. The flowers are about 1·5 times larger than those of the diploids (Pl. II, Fig. 6) and all the floral parts show increase in size, this being most marked in the corolla (124 per cent.) and ovary (53 per cent.). The number of stamens does not increase but fasciation of filaments into bundles of 2–8 is noticed in all the flowers (Fig. 8) and at least 2 such bundles are a feature of every flower. The rest of the stamens are free. The pollen grains are, as compared to those of the diploids, large and slightly more roundish. The dimensions are given below:—

	Length (μ)	Breadth (μ)
$4n$	48·59	43·03
$2n$	36·85	32·21

In cross-sections from corresponding regions of plants with equal basal diameter and at similar stage of maturity, the differences in the total number of fibre bundles in the first layer adjacent to the cambium and the shape of the fibre bearing wedge indicate the differences in the yield of the plant with some degree of accuracy. The ratio between the number of bundles in the first layer and the average number of bundles in the wedge, called the wedge ratio, is also a measure of the fibre content (1955). Larger number of bundles in the first layer, broader wedges and higher wedge ratios are associated with greater fibre content. The number of bundles in the first layer of tetraploids ranges between 480 and 543, the average number of bundles at the base of the wedge is 6·63 and the wedge ratio is 5·46. The corresponding values for control are 846–897, 9·20 and 4·66. The average number

of bundles in the wedge in 4 *n* is 39·67 and in normal 42·90. Though the length of the wedge decreases by about 12 per cent. (Pl. II Figs. 10 and 11) the number of fibre layers increases. In spite of the increase in the wedge ratio and the number of fibre layers, as the number of bundles in the lowermost layer is less and the wedges are narrower, the average number of bundles (in the entire cross-section) in tetraploids (2793) is lower than in controls (4062) of similar base diameter.



TEXT-FIG. 1. Diagrammatic representation of the average number of fibre bundles in the corresponding fibre layers of the wedge of diploid (right) and tetraploid (left). Note the large number of fibre layers in the tetraploid and larger number of fibre bundles in the diploid.

Significant differences were not noticed in the number of bundles in the wedge or in the number of ultimate fibres in the bundle which is 20·52 in 4 *n* and 20·44 in 2 *n* plants. However, the tetraploids showed increase in the length, breadth and size of the lumen of ultimate fibres but the thickness of the wall did not increase as shown below:—

	4 *n* (μ)	2 *n* (μ)
Length* ..	2121·81	1609·25
Breadth* ..	22·63	17·56
Lumen* ..	10·86	6·38
Thickness of wall†	5·92	5·59

* P = 0·01; † P = large.

The figures given above are averages of 250 readings. On statistical analysis, except the thickness of wall all the others are significantly different at one per cent. level.

Rao *et al.* (1944–45) have already pointed out that increase in the size of the tetraploids of *C. capsularis* was due, in almost all cases, to the increase in size of the individual cells rather than their number. The data on the fibre bearing portions (Text-Fig. 1) show that the height of the fibre wedge decreased though the number of bundles in the wedge and the number of ultimate fibres in the bundle remained fairly constant. But as the average total number of wedges in the transverse section is

$$\frac{\text{Average number of bundles in the first layer}}{\text{Average number of bundles in the first layer of the wedge}}$$

it is seen that the gross fibre content has greatly decreased in the tetraploids.

Yield studies.—The yield of fibre from the tetraploids was not studied in the C_1 and C_2 generations as the population was inadequate in both the years. Sufficient seed was, however, obtained in some of the selections of the C_2 generation and in 1952, 5 progenies from two elites, 5051 and 5053 and 10 progenies from 5092 were tried out in a family block trial in 6 replications along with the diploid parent C.G. and an improved strain of *C. olitorius*, JRO-632. The 10 selections of the elite 5092 were treated as two families of 5 progenies each; thus 6 families including two controls, C.G. and JRO-632, were tried out. The results summarised below give the number of plants emerging, plants harvested, fibre yield and other details.

TABLE III

Results of the tetraploid yield trial 1952

Family	No. of seeds sown	No. emerged	% of germination	No. of plants harvested	% of plants harvested against seeds germinated	Fibre yield (gm.)	Fibre yield per plant (gm.)
JRO-632	3120	1907	61·12	1458	76·46	21049	14·43
C.G.	3120	1390	44·55	1116	80·29	13828	12·39
5051	3120	1144	36·67	810	70·80	10346	12·76
5092(2)	3120	1068	34·23	683	63·95	7383	10·81
5053	3120	990	31·73	662	66·87	7335	11·08
5092(1)	3120	1058	33·91	731	69·09	7176	9·81
C.D.		464·88		384·73		3104·53	
P		0·01		0·01		0·01	

(Seeds sown in two rows per plot at the rate of 2 seeds per point, points 6″ apart in rows 13′ long and 1′ apart. Number of replications—6.)

In 1953, when the tetraploids were in the C_4 generation, 15 progenies of the elite 5051 which performed best among the tetraploid lines during the previous year and 5 progenies of each of 5053, 5092 and 5095 were again tried out in a family block trial consisting of 6 tetraploid families and 2 controls. The results are summarised below.

TABLE IV

Family	No. of seeds	No. emerged	% of germination	No. of plants harvested	% of plants harvested against seeds germinated	Fibre yield (gm.)	Fibre yield per plant (gm.)
JRO–632	2880	1107	38·44	753	68·02	14444	19·18
C.G.	2880	959	33·30	658	68·61	10591	16·10
5095	2880	830	28·82	499	60·12	6339	12·70
5051(1)	2880	707	24·55	443	62·66	6239	14·08
5051(2)	2880	776	26·94	479	61·73	6206	12·96
5051(3)	2880	734	25·45	412	56·13	5941	14·42
5092	2880	761	26·42	450	59·13	4564	10·14
5053	2880	722	25·07	409	56·65	4471	10·93
C.D.		220·38		164·03		2189·88	
P		0·01		0·01		0·01	

(Seeds sown in one row per plot, at the rate of 2 seeds per point, points 4″ apart in rows 16′ long and 1′ apart. Number of replications—6.)

In laboratory tests, all the viable seeds of C.G., which recorded a germination percentage of 99·70, germinated at the end of the first day. In tetraploids, however, the germination was slower, 58·49 per cent. of the seeds germinated at the end of the first day, 31·29 per cent. at the end of the second day, 7·16 per cent. at the end of the third day and the balance of 3·06 per cent. failed to germinate. Though the difference in the percentage of germination of normal and tetraploid seeds is not considerable, the results of field tests show that the slow germination of tetraploid seeds affects normal emergence under field conditions. The yield per plant in the case of tetraploids is also lower. The yield in all the tetraploid families was significantly below that of the two diploid controls during both the years. In spite of the low population and the resulting increase in the available space, the $4n$ plants failed to attain significantly greater height or basal diameter. The average height and basal diameter of $4n$ are 107·56 inches and 1·48 cm. and those of the diploid parent C.G. are 124·28 inches and 1·52 cm.

The yield of fibre in jute bears a direct and positive correlation with the height and the basal diameter of the plant, the coefficient of correlation for yield with height being 0·761 and that with basal diameter being 0·914 (Ghose and Patel, 1945). In the C_4 generation single plants were collected for studies on the fibre content of the plants and the correlation of fibre yield with height and basal diameter (B.D.) was worked out. The results are given below:—

Elite	*r* (Yield and height)	*r* (Yield and B.D.)	Fibre percentage (Fibre weight/ green weight)
5051	0·6993	0·8095	6·428
5053	0·7354	0·8758	5·643
5092	0·5176	0·8353	5·377
5095	0·7330	0·8045	5·866
C.G.	0·6952	0·8884	5·415

The basal diameter which in normal diploids has higher correlation with yield, gave in most cases lower correlations in the tetraploid lines. Though higher values for correlation of height with the fibre yield have been obtained in three of the elites, the combined effect of slight increase of one and marked reduction of the other results in lower out-turn of fibre as the average height of the tetraploids is significantly lower. These factors when considered along with the reduced germination under field conditions tend to point to the fact that the cultivation of tetraploids for fibre is uneconomical. But the high fibre-content of elite 5051 shows, however, that tetraploidy may not be altogether detrimental in *C. olitorius*.

The pods of the 4*n* plants are short and thick and are 3·45 cm. in length and 0·58 cm. in thickness as compared to 5·09 and 0·51 cm. of the normal pods (Pl. II, Figs. 7 and 8). In spite of the high fertility of pollen grains, the number of healthy seeds in the capsules of raw tetraploids is very low. Bhaduri and Chakrovarti (1948) observed that in *C. capsularis* tetraploids the average number of seeds ranged from 0–4 in each capsule in the earlier generations and by judicious selection the number could be increased to 5–20. Improvement in fertility was effected in the present case by (*a*) selecting within the elite, plants with largest number of pods and (*b*) by using pods with the highest number of seeds (healthy and floaters included) for propagating the elite in successive years. By this method the number of healthy seeds per pod was increased by over 300 per cent. A slight fall in the number of seeds was, however, recorded in 1954.

TABLE V

Average number of good and bad seeds in the pods

Elite	1950		1952		1953		1954	
	Good	Bad	Good	Bad	Good	Bad	Good	Bad
5051	13·30	0·00	36·49	5·48	43·55	8·60	35·03	4·17
5053	14·71	16·14	36·33	7·92	36·65	10·40	42·64	7·00
5092	24·84	14·83	37·81	8·36	42·65	8·50	38·53	4·18
5095	14·70	7·00	40·64	6·48	51·60	9·11	43·25	4·10
C.G.	157·58	3·48	155·45	4·38	171·43	6·32	162·83	5·84

The good seeds are large (Pl. II, Fig. 9) and weigh about 330 seeds whereas normal seeds of C.G. weigh about 500 per gram. The colour and shape are not much different from those of the normal though the leek-green colour in the case of the tetraploids tends to be slightly more greenish. The bad seeds are shrunk, light in weight and have an unhealthy appearance. A number of them (floaters) were dissected and it was observed that they were invariably empty though the size attained by them was only slightly below that of the healthy seeds.

Beginning from the year 1951 when tetraploid plants of both *C. olitorius* and *C. capsularis* were available in sufficient numbers, about 30 crosses were made each year between them but viable seeds were not obtained. In a large proportion of crosses attempted, the pollinated flowers dropped off within 24 hours and many of the rest before 72 hours. The results, thus, were even more disappointing than the crosses between the diploids of the two species attempted each year, where development of pollinated flowers into fruits is obtained in about 5 per cent. of the cases, though the seeds resulting from such crosses are 'floaters' and invariably fail to germinate. The small proportion of pods that develop from crosses between the tetraploids of the two species have an unusually thick pericarp; about a dozen seeds obtained during these 3 years were shrunk and had an unhealthy appearance and failed to germinate on sowing. It appears that the two species have to be hybridised by methods other than the ones so far practised.

DISCUSSION

Though autopolyploids of a number of crop plants have been produced and studied, very few bast fibre plants except flax have received detailed attention in this respect. Tetraploids have been produced in flax (Levan, 1942, 1948; Masima, 1942, etc.), *Hibiscus cannabinus* (Badenhuizen, 1941; Toxopeus, 1948, etc.), *H. sabdariffa* (Toxopeus, 1948), *Cannabis sativa* (Nishiyama, 1941) and jute but in most cases

except flax studies have been restricted to the morphological and not economically important variations. Badenhuizen (1941) treated *H. cannabinus* with colchicine and observed that the 4 *n* plants were less branched though they showed, besides other variations, giganticism of stomata, epicalyx, petals, and seeds. The differences in the rate of growth of 2 *n* and 4 *n* plants were not very marked but he expected that the tetraploids would combine higher yield with greater resistance to diseases. Reduction in the number of branches on the increase of the number of genomes has also been observed in flax by Levan (1942) who found that the branches were also shorter. Ramanujam and Parthasarathy (1953) quoted the unpublished records of the Indian Agricultural Research Institute and stated that instances of increased branching and branches of a higher order than the diploid are not infrequent in some flax types. In the present instance, the autotetraploids of *C. olitorius* are more branched than the diploids.

Levan (1942) also observed that slight increases in height were noticeable in the tetraploids of linseed types but in the case of flax types reduction in the height was more frequent. This was stated to be due to the selection in the fibre flax of genes for tallness which exhausted the possibilities of desirable variations in that direction whereas in linseed types which were bred for seed irrespective of height, the reserve stock of genes for tallness showed up on multiplication of genomes (Kuckuk and Levan, 1951). The straw weight of the tetraploids of flax was only 53·3 per cent. of the diploid. A similar state of affairs exists in the case of tetraploids of cultivated *olitorius* where intensive selection for height and fibre yield has been practised for a number of years and doubling of chromosomes results in lowering of both height and yield.

Toxopeus (1948) obtained tetraploids of *Hibiscus cannabinus* and noticed that they were more vigorously growing and had enlarged diameter of ultimate fibres and other elements of bark and wood. It is rather unfortunate that all his plants were sterile and their yield could not be studied in the C_2 and subsequent generations when larger population is usually available.

The vigour in the early stages of growth of 4 *n* *C. olitorius* is only slightly below that of normal plants though the broad leaves of tetraploids present a healthy appearance to the plants till they get attacked by 'scalding'—an unidentified disease.

The chimæral nature of a large proportion of the C_1 plants has been reported by several workers in a number of crops. Ramanujam and Joshi (1941) treated seeds of *Cicer arietinum* and obtained periclinal chimæras. Baker (1943) treated dry seeds of potato—a natural tetraploid—and obtained periclinal chimæras with 8 *n* epidermis and 4 *n* core but in the first tuber generation these revealed only normal potato plants with 4 *n* tissues. Bhaduri *et al.* (1948) stated that in *C. olitorius* periclinal chimæras as evidenced by plants with 2 *n* and 4 *n* branches were occasionally found among the treated plants. But, it is not clear how these chimæras were obtained as they treated both seeds and seedlings and

obtained tetraploids. The present authors observed that seeds from separate pods collected from different branches of C_1 plants gave progenies which were either diploid or tetraploid. The progenies of the seeds of any single pod were only of one type. The mixture of pods obtained even in the same branch shows that the chimæras were mericlinal or periclinal resulting in tetraploid fruits from the affected regions. Adequate proof of sectorial chimæras could not be obtained during the present studies.

Pods in the C_1 generation were collected from plants showing a degree of morphological variation definitely distinct from the normal plants and though pods from 21 such plants were grown in the C_2, only four plants gave tetraploid progenies. Even of these four, only a single plant was a pure tetraploid. Thus most of the plants of the C_1 showing variations appear to be affected only superficially and heritable variations are few and rare.

The tetraploid seeds of *C. olitorius* germinate more slowly and this lack of quick response to moisture leads to reduced germination under field conditions. Similar observations have been made by Noguti, Oka and Otuka (1940) in *Nicotiana*, Newcomer (1941) in cabbage and Levan (1948) in red clover. The moisture content in jute fields at the time of sowing is often inadequate and capacity for quick germination is a highly desirable character in jute. Normal *C. olitorius* jute seeds retain viability for about 3 weeks under conditions of insufficient moisture and germinate in 2 or even 3 instalments. Tetraploids, on the other hand, germinate in a single instalment and in the event of drought the rest of the seeds perish. So far as survival during the period of growth is concerned, though a large proportion of plants reach the harvest stage in both the types, the percentage of survival in the tetraploid was less. It would, anyhow, be too early to draw definite conclusions about the ability of tetraploids to grow normally as they have not been found to be more susceptible to diseases.

Studies conducted at the Institute show that in normal plants, upto a certain limit, the yield of individual plants increases with increase in spacing between them (1945). The yield in the tetraploid families was significantly lower, though, during both the years, the average space available to the $4n$ plants was 59·25 per cent. more than that available to the diploid C.G. as the population in the $4n$ families was only 62·80 per cent. of the C.G. families. Even in the best tetraploid family 5051, the average single plant yield was less than that of C.G.

The observation that the ultimate fibres increased both in length and thickness, the latter mainly due to increased breadth of the lumen than the thickness of the wall, corroborates the studies of Rao *et al.* (1944–45) in *C. capsularis* and the general observation that the increase in the case of polyploids is in the size rather than the number of individual cells. Bhaduri and Chakrovarti (1948) stated that the total volume of fibre as compared to the diameter of the stem increases and felt that it would be better to find out if this leads to increase in the

yield of fibre. From the anatomical evidence it is difficult to conclude that the volume of fibre increases as it is seen that the fibre bearing wedges are distinctly narrower and the gross fibre content of tetraploids decreased by about 40 per cent. as compared to diploids of equal base diameter. The fewer and narrower fibre bearing wedges, smaller number of fibre bundles in the lowermost bast layer and the increased volume of individual cells with wider lumens have cumulative effect in reducing fibre yield.

Though increase in size is noticed in the leaf, floral parts, seed, etc. the fruit in tetraploid *C. olitorius* is smaller. The diameter of the pod increases but the length decreases even more resulting in a reduction in the total volume of the fruit. This is in contrast to the observations made by Rao *et al.* (1944–45) in *C. capsularis*, Uchikawa (1947) in *Cucurbita*, Hartman (1950) in *Cucumis melo* var. *flexuosa*, Derman (1954) in grapes and others who noticed that increase in the number of chromosomes leads to fruits of larger size. Batra (1952), however, obtained fruits of smaller size in tetraploids of musk melon.

It has already been pointed out that meiotic irregularities are few and the fertility of pollen is sometimes even higher than that obtained in normal plants. The total number of ovules in the ovary is lower and so the total number of seeds including the 'floaters' was lower in the fruits of all the tetraploids. Similar observation was made by Schwanitz (1951) who found that in some of the crops he investigated, the number of ovules in the ovary is fewer in the polyploid state and this was correlated with low seed-set. The number of healthy seeds in tetraploid *C. olitorius* was increased by selecting in successive generations, plants with the largest number of pods and again by propagating each line by using seed from pods bearing the highest number of seeds including the 'floaters'. The success attained by this method is considered to be fair as the number of healthy seeds increased by a little over 300 per cent. and the number of 'floaters' showed a general downward trend thus showing that definite increase in the number of ovules in the ovary was obtained. Levan (1948) found that in raw tetraploids of seed flax the seed yield is only about 40 per cent. of that of the diploid but when selected for seed production the yield could be increased to about 60 per cent. and the best lines even equalled the diploid. Kuckuk and Levan (1951) stated that such improvement in seed yield was more marked in families exhibiting low fertility in the beginning. Müntzing (1951) isolated populations of tetraploid rye with nearly 85–90 per cent. of the yield of diploids by selecting within the tetraploid lines over about 9 years. Parthasarathy and Rajan (1953) worked with the tetraploids of *Brassica campestris* var. *toria* and by the 'mass pedigree method' of Harland (1949) increased the number of seeds per siliqua to almost the level of the diploid. In all these cases the greater weight of tetraploid seeds often tends to compensate the decrease in their number; thus the yield (weight) of seeds per plant is not markedly lower in grain crops. But in a bast fibre crop like jute what is more necessary is the increase in the number of viable seeds irrespective of the weight of individual seeds. In the case of

C. olitorius tetraploids the seed weight of healthy seeds did not increase in successive years. Though some increase in the number of healthy seeds was obtained, it must yet be admitted that the number of seeds in the fruits is very low and stands poor comparison with the normal diploid.

Summary

Seeds of *C. olitorius*, variety C.G., were treated with 5 concentrations of colchicine ranging from 0·0125–0·150 for 5 different periods from 3 to 24 hours. The effective concentrations for induction of tetraploidy range from 0·0125–0·10 per cent. of colchicine and duration from 6 to 24 hours. Higher concentrations are more effective even when shorter periods of treatment are used.

Periclinal and mericlinal chimæras were obtained by the treatment but the progenies of each pod were found to be pure, either diploid or tetraploid.

The tetraploid seeds germinate more slowly and this character affected the germination under field conditions adversely. The leaves, stomata, floral parts, pollen grains and seeds are all larger in the tetraploid *olitorius*. The plants are shorter and more branched. The tetraploids flower along with the diploids but the period of flowering is prolonged by about a month. The filaments of some stamens are united into bundles of 2–8 though the anthers are free; each flower has at least two such staminal bundles.

In spite of occasional meiotic irregularities, the pairing of chromosomes is normal and the fertility of pollen is satisfactory.

The number of fibre bundles in the first layer adjacent to the cambium and the number of bundles in the fibre wedge decrease though the reduction in the latter is only slight. The length of the fibre bearing wedge also decreases but the number of fibre layers in the wedge increases. The ultimate fibres are longer and thicker though the increase in thickness is due to larger lumen than thicker wall. The volume of fibre shows a slight reduction.

The yield of fibre in all the tetraploid families is significantly lower than that of the diploids.

The pods of tetraploids are smaller in size and the number of ovules in the pods is low. By selecting plants with the largest number of pods and pods with the highest number of seeds, including bad seeds, about 300 per cent. increase in the number of seeds per pod was obtained in about 3–4 years.

Acknowledgement

The authors express their thanks to Mr. B. Das Gupta, Botanist of this Institute, for help in planning the yield trials. Thanks are also due to Mr. S. K. Mahalanabis, for helping in field studies.

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EXPLANATION OF PLATES

PLATE II

FIG. 1. Metaphase I of tetraploid showing 2 IV, 1 III, 7 II and 1 I. Two other univalents are out of focus, ×900.

FIG. 2. Restitution nucleus, ×900.

FIG. 3. Metaphase I of tetraploid showing 2 IV, 1 III, 6 II and 3 I. Two other univalents are slightly out of focus and are just visible lower left of tetravalent ring, ×2,100.

FIG. 4. Hexad. Five spores are seen within and one outside which has come out through a puncture in the wall of the mother cell; ×640.

FIG. 5. Fasciation of filaments: the anthers are usually free. See text for explanation, ×10.

FIG. 6. Flowers of (*a*) tetraploid and (*b*) diploid, ×1/3.

FIG. 7. Capsules of diploid, ×2/5.

FIG. 8. Capsules of tetraploid, ×2/5.

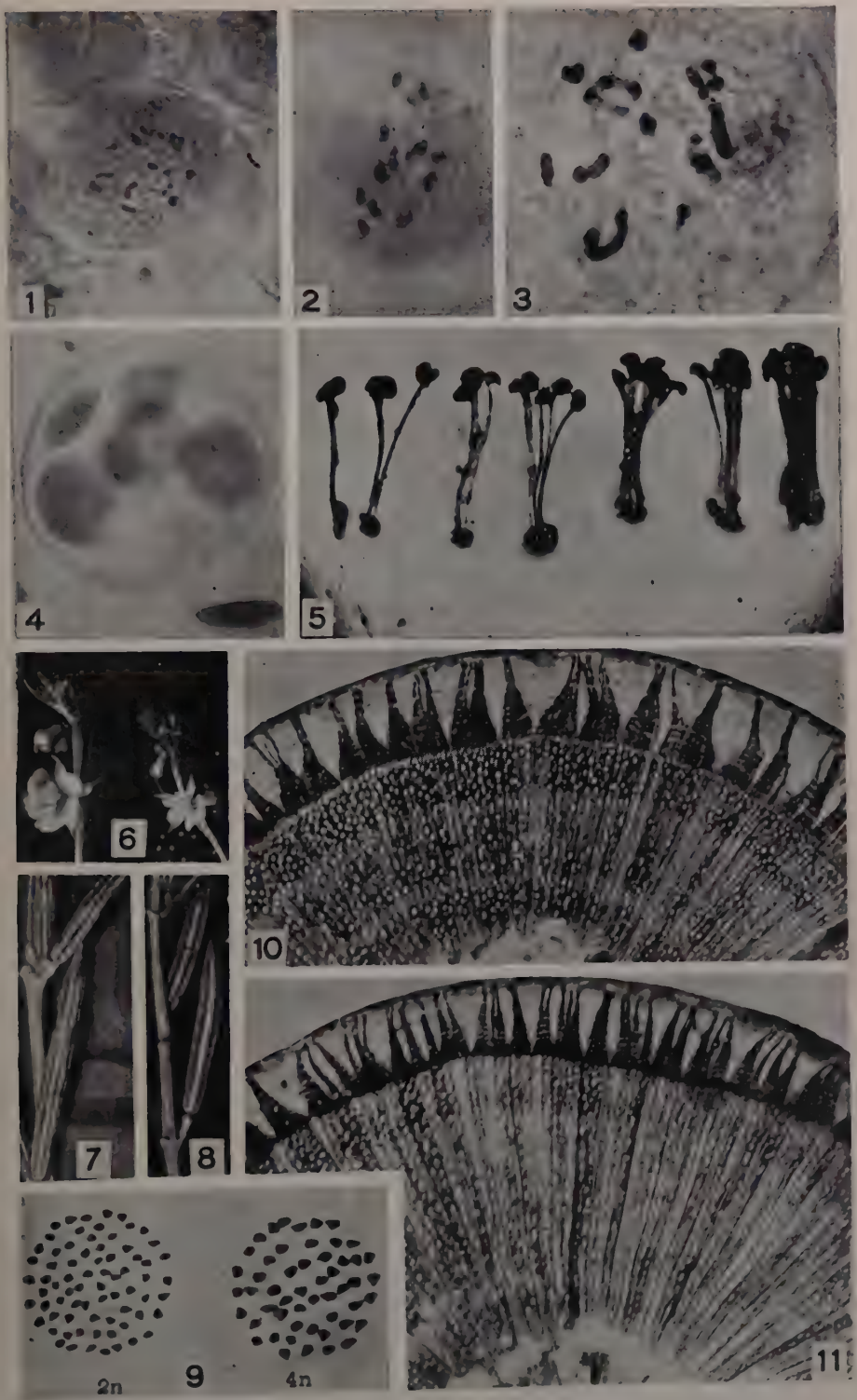
FIG. 9. Seeds of diploid and tetraploid, ×½.

FIG. 10. T.S. of stem of diploid showing fibre wedges, ×10.

FIG. 11. T.S. of stem of tetraploid showing fibre wedges. ×10. Note that the wood is thicker in tetraploid.

PLATE III

FIGS. 1 and 2. Top portions of tetraploid and diploid plants. Note the wider leaves in the tetraploid.



B. C. Kundu and M. S. Sarma

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SOME SLIME-MOULDS FROM SOUTHERN INDIA—IV

By V. Agnihothrudu

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(Received for publication on October 29, 1955)

13. *Didymium crustaceum* Fries in *Syst. Myc.*, **3**: 1829, p. 124; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 118-119; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 121.

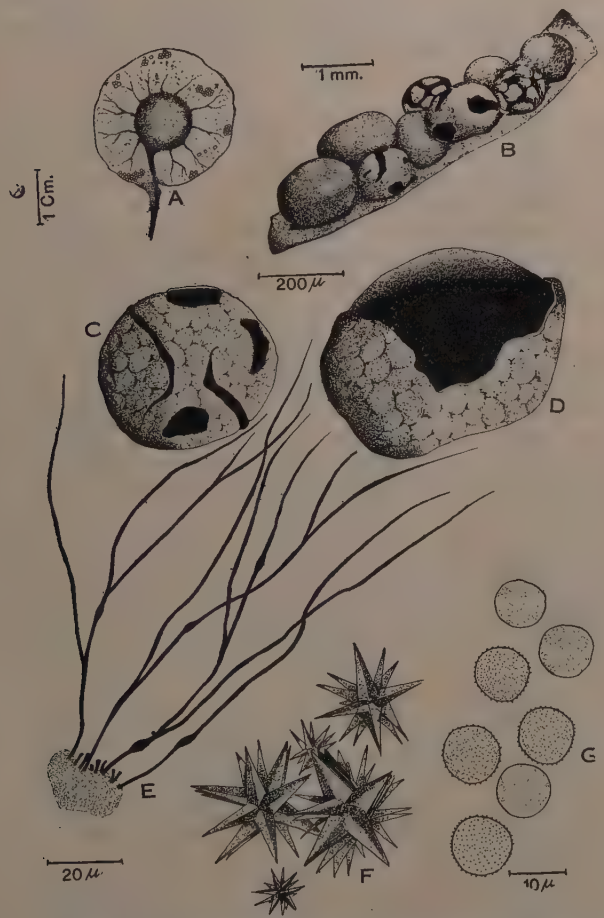

Fig. 1. *Didymium crustaceum* Fries.—A. Sporangia on a fruit of *Pterocarpus marsupium*. B. Gregarious sporangia on a decomposing twig. C and D. Indi-

vidual sporangia showing the scaly nature of peridium and the method of dehiscence. E. Capillitial threads showing fusiform enlargements. F. Calcareous crystals in the peridium. G. Spores.

Plasmodium not observed. Sporangia closely aggregate, often confluent, rarely separate, spherical or subglobose, not infrequently deformed by mutual compression. In all the collections examined the sporangia were sessile, measuring 0·5–2 mm. in diameter, smooth snow-white. Peridium well developed, crustaceous, composed of loosely compacted lime crystals, extremely frail and fugacious and falling off in flakes exposing the spore mass. When the crust has fallen off the sporangia appear hemispherical and ashen grey. Hypothallus scanty and evanescent, concealed under the sporangia, evident only after the spore dispersal. Capillitium consisting of stout pale violaceous threads, scantily branched, 0·5–1·0 μ in diameter, often with fusiform enlargements. Columella absent. Spores violaceous brown, globose to spherical measuring on average 11·8 μ, range 9·6–12·8, mostly 12·2 μ.

On dead twigs and fruits of *Pterocarpus marsupium* Roxb. Agri-Horticultural Gardens, Madras, 8–8–1954 (Herb. M.U.B.L. No. 1220). On dead twigs of *Nyctanthes arbor-tristis* L., Ayanavaram, Madras, 10–8–1954 (Herb. M.U.B.L. No. 1221); On dried leaves of *Antigonon leptopus* Hk. and A., Soundarya Nursery, Madras, 10–9–1954 (Herb. M.U.B.L. No. 1222); On decomposing leaves of *Porana volubilis* Burm., Perambur, Madras, 16–9–1954 (Herb. M.U.B.L. No. 1223). All the collections were made by V. Agnihothrudu.

14. *Didymium clavus* (Alb. and Schw.) Rabenhorst, in *Deutsch. Krypt. Fl.*, i, 1884, p. 280; as *Didymium commutabile* Berk. and Br. *J. Linn. Soc.*, **14:** 1873, p. 83; as *D. masseeanum* Sacc. and Syd., in *Syll. Fung.*, **14:** 1899, p. 836; as *D. clavus* (Berk. and Schw.) Rost. Schinz, in *Rabenhorst's Kryptogamen Flora*, Abt. X, p. 210; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 122; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 114; Petch, *Ann. R. bot. Gdns., Peradeniya*, **4:** 1909, p. 348; Brühl and Sen Gupta, *J. Dep. Sci. Calcutta Univ.*, 1927, p. 116.

Plasmodium not observed. Sporangia gregarious, scattered, discoid, orbicular or pileate, stipitate, snow-white to ashen-grey in colour and at times mottled. Total height of the fructification 0·5–1 mm., sporangium proper measuring 0·5–1 mm. in diameter and about 0·2 mm. thick with thin peridium encrusted with calcareous crystals. In some cases the sporangium is naked below. Stalk cylindrical, solid, longitudinally furrowed, dark brown to almost black in colour with a well-developed hypothallus. Stipes are broad below, tapering towards the sporangial end. In some collections, the stipe was seen to narrow down so abruptly that the discoid sporangium is almost nodding. Columella absent. Capillitium well developed, consisting of pale purple threads spraringly branched. Spore mass fuliginous, spores individually violaceo-fuscous, almost smooth, measuring on average 7·6 μ, range 6·4–8·4 μ and mostly 8·0 μ.

FIG. 2. *Didymium clavus* (Alb. and Schw.) Rab.—A. Sporangial aggregation on a twig. B, C, D and E. Showing sporangia of different shapes, the stipe and the hypothallus. F. A dehisced sporangium showing the unbroken sporangial base and the spore mass. G. Capillitial threads. H. Stellate crystals of the peridium. I. Spores.

On twigs of *Ocimum canum* Sims., University Botany Field Laboratory campus, 15–8–1954 (Herb. M.U.B.L. No. 1224); On dead leaves of *Terminalia paniculata* Roth., Agri-Horticultural Gardens, Madras, 15–8–1954 (Herb. M.U.B.L. No. 1225); on dried leaves of *Antigonon leptopus* Hk. & A., Marina, Madras, 18–10–1954 (Herb. M.U.B.L. No. 1226); on twigs of *Malvastrum* sp. Kilpauk, Madras, 15–10–1954 (Herb. M.U.B.L. No. 1227); on decomposing twigs of *Croton sparsiflorus* Morung., Villivakkam, Madras, 18–8–1954 (Herb. M.U.B.L. No. 1228). On dead twigs of *Peltophorum ferrugineum* Benth., Queen Mary's College campus, Madras, 12–9–1954 (Herb.

M.U.B.L. No. 1229); on leaves of *Porana volubilis* Burm., Kodambakkam, Madras, 20–9–1954 (Herb. M.U.B.L. No. 1230). All the collections were made by V. Agnihothrudu.

15. *Didymium squamulosum* Fries in *Symbolæ Gasteromycorum*, 1818, p. 19; as *Didymium effusum* Link, Lister, *Mycetozoa*, 1894, p. 99; as *Didymium squamulosum* (Alb. and Schw.) Fries, Macbride, *The North American Slime-Moulds*, New ed., 1922, pp. 119–121; Lister, *A. Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 117–18.

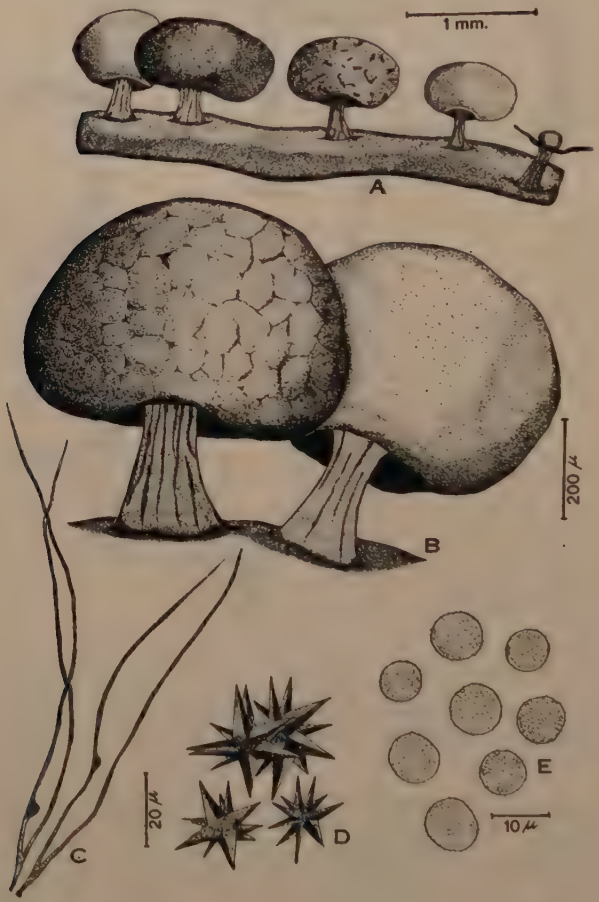

FIG. 3. *Didymium squamulosum* Fries.—A. Twig with sporangia. Well-developed columella is seen in the dehisced sporangium. B. Sporangia showing scaly and smooth peridial walls and a well-developed longitudinally striate stipe. C. Capillitial threads with irregular thickenings. D. Stellate crystals in the peridium. E. Spores.

Plasmodium not observed. Sporangia gregarious, typically globose or depressed-globose to sub-hemispherical, umbilicate, 0·4–1·2 mm. in diameter, snow-white to pale grey in colour, stipitate. Sessile forms were not observed. Peridium smooth, white or mottled, thin membranous impregnated with abundant stellate calcareous crystals, breaking away in the form of scales. Stipe short, stout, varying in length from 200–500 μ and up to 250 μ broad with an incipiently developed hypothallus, white or pale yellow grey, deeply furrowed with deposits of small calcareous crystals. The peridium breaks up and after spore dispersal the prominent white hemispherical to subglobose columella is distinctly visible. Capillitium well developed, composed of coarse, sparingly branched threads, purplish brown, hyaline at the ends with irregular thickenings at the base. Spores appearing deep violaceous brown *en masse*, individually pale violaceous, spherical, distinctly verrucose, measuring on average, 10·1 μ, range, 7·8–10 μ, mostly 10 μ in diameter. Only one collection was made.

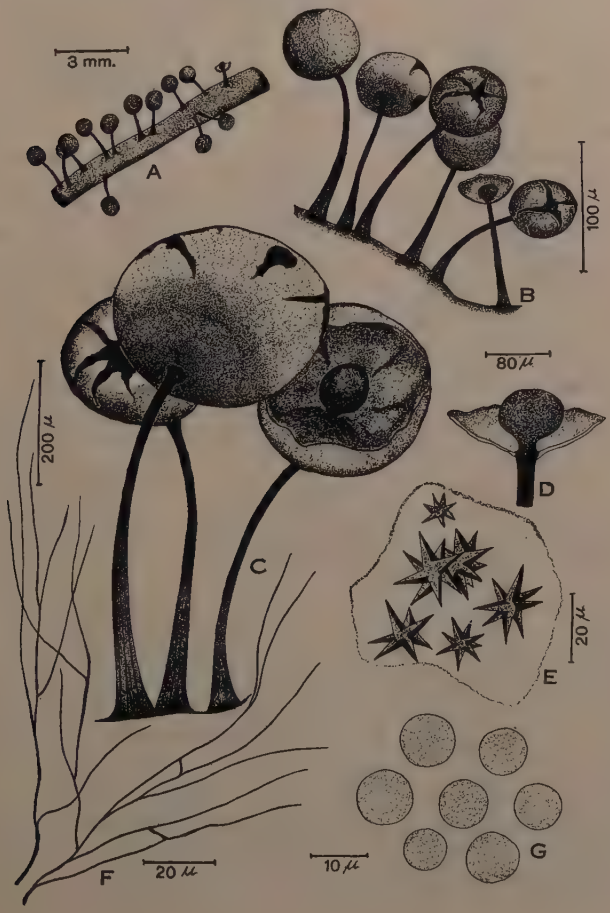

FIG. 4. *Didymium nigripes* (Link.) Fries.—A. Sporangial aggregate on a twig of *Pterocarpus marsupium*. B and C. Spo angia showing the long stipe and radiate dehiscence. D. Columella. E. Stellate calcareous crystals in the peridium. F. Capillitial threads. G. Spores.

On dead unidentified twigs, Mylapore, Madras, 29–9–1954, coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1231).

16. *Didymium nigripes* (Link) Fries in *Syst. Myc.*, III, 1829, p. 119; Saccardo, *Syll. Fung.*, **7:** 1888, p. 382; as *Didymium microcarpon* Fries, Petch, *Ann. R. bot. Gdns., Peradeniya*, **4:** 1909, p. 348; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 123; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, p. 116; Lodhi, *Publ. Univ. Punjab*, 1934, p. 13.

Plasmodium not observed. Sporangia gregarious, globose, subumbilicate, stipitate, measuring 0·75–1·5 mm. in total height. Sporangium proper measuring 0·5–0·75 mm. in diameter. Sporangial wall membranous, white to pale greyish brown in colour, profusely charged with stellate calcareous crystals, dehiscing laciniately or in some collections radiately, exposing the spore mass. Stalk long, measuring up to 1 mm., cylindrical, straight or slightly bent, longitudinally striate, broader at the base with a scutate hypothallus, slightly tapering towards the sporangial end, olive brown above, deep brown or ochraceous at the hypothallic end due to enclosed refuse matter. Sporangium lodges a distinct spherical to subspherical columella dark brown in colour and impregnated with irregular angular lime crystals. Capillitium well developed, consisting of purplish brown threads, sparingly branched. Spores fuscous brown *en masse*, individually pale violaceous brown, smooth, measuring on average 9·8 μ, range 8·0–10·8 μ, mostly 10 μ in diameter.

On dead twigs of *Pterocarpus marsupium* L., Agri-Horticultural Gardens, Madras, 22–8–1954 (Herb. M.U.B.L. No. 1232); on unidentified decomposing leaves, Ayanavaram, Madras, 26–8–1954 (Herb. M.U.B.L. No. 1233). All the collections were made by V. Agnihothrudu.

17. *Didymium melanospermum* (Persoon) Macbride in *The North American Slime-Moulds*, 1899, p. 88; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 121; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 114–116.

Plasmodium not observed. Sporangia gregarious, globose or hemispherical or depressed, deeply umbilicate below, typically stipitate, measuring 0·4–1·25 mm. in total height, sporangium proper measuring 0·5–1·0 mm. in diameter. Peridium frosted with minute stellate crystals of lime, white to ashen grey in colour, breaking irregularly. Stalk terete, straight, stout, deep brown to dull black in colour smooth or slightly striate, measuring 0·4–0·8 mm. long, up to 200 μ thick, enclosing refuse matter with a well-developed hypothallus. Columella well developed evident after spore dispersal, hemispherical, umbilicate, rough enclosing nodules of lime. Capillitium well developed, stout, scantily furcate, pale purple brown in colour showing no thickenings.

Spores appearing dark brown to almost black in mass, deep purplish grey in transmitted light, spinulose spherical to subspherical, measuring on average 11·0 μ, range 9·6–11·8 μ, mostly 11·2 μ in diameter.

On dead twigs of *Tamarindus indica* L., Kilpauk, Madras, 8–9–1954 (Herb. M.U.B.L. No. 1234); on dead unidentified twigs, Elliots beach, Madras, 15–9–1954 (Herb. M.U.B.L. No. 1235). All collections were made by V. Agnihothrudu.

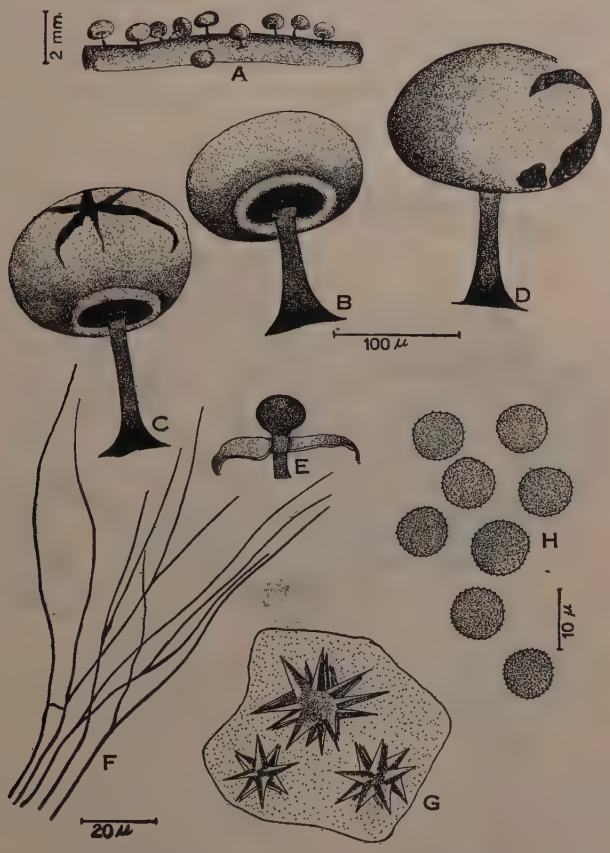

FIG. 5. *Didymium melanospermum* (Pers.) Macbride. A. Sporangia on dead twig of *Tamarindus indica*. C. An individual sporangium showing the umbilicate nature and the well-developed stipe with the hypothallus. D. Sporangium showing the flaky dehiscence. E. Comluella. F. Capillitial threads. G. Stellate crystals in the peridium. H. Spores.

18. *Perichæna vermicularis* Rostafinski in Appendix to *Sluzowce* (Mycetozoa) *Monografia*, 1876, p. 34; as *Ophiotheca vermicularis* Massee, Macbride in *The North American Slime-Moulds*, New ed., 1922, p. 240; as *P. variabilis* Rost., Lister, *Mycetozoa*,

1894, p. 199; Petch in *Ann. R. bot. Gdns., Peradeniya*, **4**: 1909, p. 370; as *P. vermicularis* Rost., Lister in *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 248–249.

Plasmodium not observed. Sporangia sessile, scattered, simple, globose to subglobose or subhemispherical somewhat narrow at the base, measuring up to 0·6 mm. in diameter. Plasmodiocarps simple, straight, or vermiform and rarely reticulate, ochre yellow or umber in colour. Peridium distinctly composed of two layers, an outer thicker layer granular in appearance enclosing small crystals of lime. This layer is closely attached to an inner thinner subcartilaginous transluscent papillose membrane. The outer thicker wall is not distinct in the upper aspect of the sporangium where usually the peridium dehisces exposing

Fig. 6. *Perichæna vermicularis* Rost.—A. Plasmodiocarps on a twig. B. Plasmodiocarps on the leaf of *Bignonia unguis-cati*. C, D, E and F. Showing sporangia and plasmodiocarps of different shapes and the method of dehiscence. G. Capillitium. H. The double-layered peridium. I. Spores.

the capillitial threads with the enclosed spore mass. Capillitium is a profuse reticulum of scantily branched threads, yellow in colour, measuring up to 3·6 μ in diameter, constricted at irregular intervals with minute warts which give it a rough appearance. Spores typically citron yellow in mass, pale yellow to almost hyaline individually, minutely but distinctly warted, spherical to sub-spherical, measuring on average 12·2 μ, range 10·8–14·0 μ, mostly 12·8 μ in diameter.

On decomposing leaves of *Bignonia unguis-cati* L., Agri-horticultural Gardens, Madras, 15–10–1954 (Herb. M.U.B.L. No. 1247); on unidentified decomposing plant twigs, University Botany Laboratory campus, Madras, 18–10–1954 (Herb. M.U.B.L. No. 1248).

19. *Perichæna depressa* Libert *Pl. Crypt. Ard.*, Fasc., **4:** 1837, p. 338; Macbride, *The North American Slime-Moulds*, New ed., 1922, pp. 242–243; Petch in *Ann. R. bot. Gdns., Peradeniya*, **4:** 1909, p. 368; Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 244–245; Saccardo, *Syll. Fung.*, **7:** 1888, p. 420.

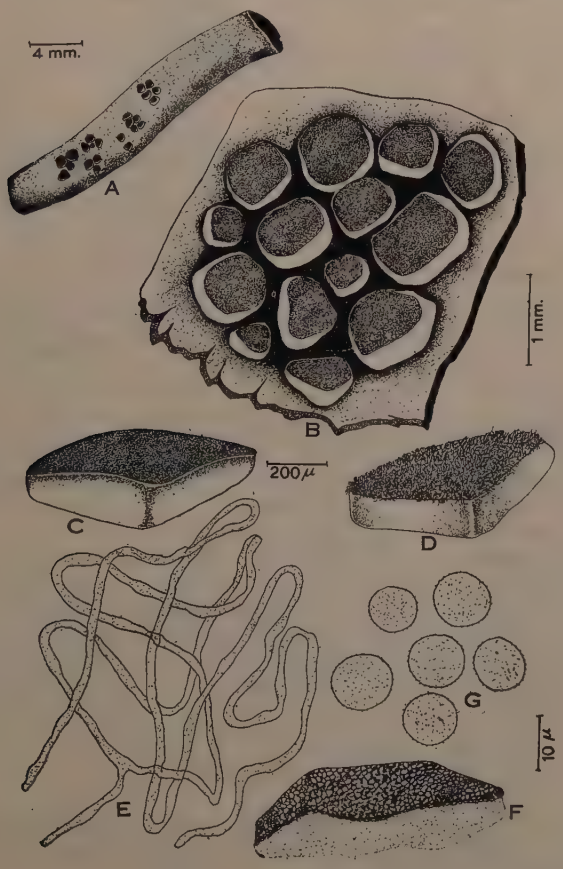

FIG. 7. *Perichæna depressa* Libert.—A. Sporangia on a twig. B. Sporangial aggregate on a leaf fragment. C. A single sporangium showing the deeply coloured operculum. D. Dehisced sporangium showing the capillitial threads. F. Double-layered peridium. G. Spores.

Plasmodium not observed. Sporangia typically sessile, flat, applanate, crowded, polygonal, up to 1 mm. in diameter. Sporangia were all simple and no plasmodiocarps were observed. Colour of the sporangium varying from deep fuscous brown or lilac to chestnut brown, upper part of the sporangium deeper in the hue than the bottom. Sporangium dehiscing by a well-defined operculum exposing the bright yellow spore mass with the capillitium lodged in the shallow spore-cases. Sporangial wall typically composed of two layers, an outer deeply coloured thick wall enclosing lime crystals closely adpressed to an inner smooth membranous transluscent layer. Capillitium a well-developed web of sparingly furcate and anastomosing yellow threads, measuring up to 3 μ in diameter with irregular thickenings. Spore pale yellow to almost hyaline in colour measuring on average, 10·8 μ, range 9·6–12·0 μ. mostly 11·2 μ in diameter.

Only one collection was made on decomposing vegetable débris. Avadi, 22–1–1955, Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1249).

20. *Arcyria ferruginea* Sauter in *Flora*, **34:** 1841, p. 316; Macbride, *The North American Slime-Moulds*, New ed., 1922, p. 253; Petch, *Ann. R. bot. Gdns., Peradeniya*, **4:** 1909, p. 365; Schinz, *Rabenhorst's Kryptogamen flora*, Abt., X, p. 371, 1920. Saccardo, *Syll. Fung.*, **18:** 1906, p. 212; Brühl and Sen Gupta, *J. Dep. Sci. Calcutta Univ.*, **8:** 1927, p. 121. Lister, *A Monograph of the Mycetozoa*, 3rd ed., 1925, pp. 229–230.

Plasmodium not observed. Sporangia gregarious, closely crowded, measuring 1–2·5 mm. in height. Sporangia typically stipitate, ovoid cylindrical up to 1·5 mm. long, orange red in colour fading into dull rose-red. Calyculus well developed, shallow infundibuliform, marked with reticulations on the inner aspect. Sporangial wall thin and evanescent, reticulate. Stalk cylindrical, up to 1 mm. long, 40–200 μ thick, pale red or almost white in colour with a basal membranous hypothallus. The stipe is filled with mass of spore-like cells. Capillitium a well-developed close reticulum of ornamented threads attached to the calyculus centrally. The capillitial threads are profusely branched, reddish yellow, measuring 4·8–6·4 μ in diameter at the base, diminishing to 1·6–3·2 μ diameter. The threads towards the base of the sporangium are triangular in cross-section with bars and close reticulations arranged in a loose and irregular spiral on one aspect with warts or broken reticulations on the other aspect. Some of the threads have free ends which are clavate and rounded. Spores pale rose coloured, spherical to globose, faintly warted, measuring on average, 9·6 μ, range 8·0–11·2 μ, mostly 10 μ in diameter.

Only one collection was made on decomposing twigs of *Bignonia unguis-cati* L. Agri-Horticultural Gardens, Madras, 24–10–1954, Coll. V. Agnihothrudu (Herb. M.U.B.L. No. 1250).

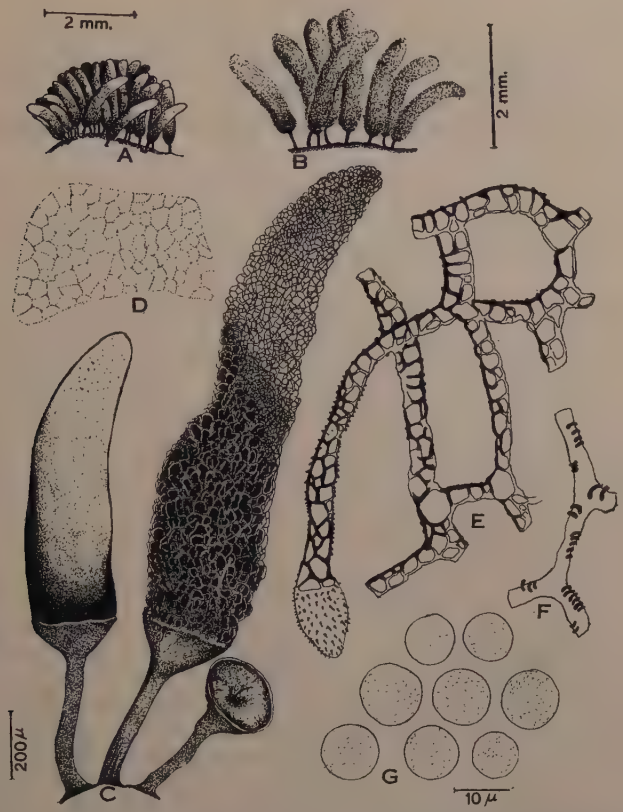

FIG. 8. *Arcyria ferruginea* Sauter.—A. Undehisced sporangial aggregate. B. Dehisced sporangia. C. Sporangia showing the well-developed stipe, calyculus and the capillitium. D. A fragment of the peridium. E. Capillitial threads at the base of the sporangium. F. Capillitial threads at the apex of the sporangium. G. Spores.

ACKNOWLEDGEMENTS

My thanks are due to Professor T. S. Sadasivan and Dr. C. V. Subramanian for their helpful suggestions in the preparation of this paper. My thanks are also due to Dr. K. Ramakrishnan for critically reading the manuscript and to the Government of India for the award of a senior scholarship.

FUNGI ISOLATED FROM RHIZOSPHERE

II. *Starkeyomyces*, A New Genus of the Tuberculariaceæ

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(Received for publication on October 29, 1955)

In the course of investigations on the rhizosphere microflora of pigeon-pea [*Cajanus cajan* (Linn.) Millsp.] plants in relation to the wilt caused by *Fusarium udum* Butler, very frequently an interesting tuberculariaceous fungus was isolated from dilution plates and root platings of plants. The same fungus was isolated from the rhizosphere of many weeds growing in and around the city of Madras and soils collected from Mount Abu (Bombay), Ahmedabad (Gujerat-Bombay), Nilambur (Malabar-Madras), Guruvayyur (Malabar-Madras), Anamalais (Coimbatore-Madras), Vijayawada (Andhra) and Bangalore (Mysore). The following is the description of the fungus:—

The fungus in culture produces abundant aerial mycelium with sporodochia which are irregular or circular in outline, separate at first but coalescing later. The spore mass appears Brunswick green (24 A 12) or Tyrolian (32 A 12) or Balsam green (32 H 5). Colour characters are recorded with the help of Maerz and Paul's *A Dictionary of Color*, McGraw-Hill, N.Y. (1930). The numerical designations corresponding to different colours in the dictionary are included in parenthesis. The sporodochia are cupulate and superficial measuring 0·5–3·0 mm. in diameter and up to 100 μ tall. The sporodochia are not fringed by any setæ or sterile hairs. The conidiophores are irregularly ramose and the ultimate branches are closely aggregated to form a hymenial layer. The conidia are produced acrogenously and singly on the tips of conidiophores and are hyaline, continuous and smooth-walled. The spores are naviculiform or fusiform-elliptic, slightly apiculate at either end. The conidium is characterized by the presence of a thin membranous appendage which is developed on the free end. The appendage could be seen with some difficulty in unstained preparations but when stained with aqueous eosin or methylene blue or fast green it could be more clearly seen. Best results were obtained when spore smears were stained with Dorner's nigrosin in the same way as for bacterial negative mounts. The conidia are mostly $7{\cdot}2\times3{\cdot}4\,\mu$ ($3{\cdot}8 - 11{\cdot}8\times2{\cdot}0 - 4{\cdot}2$) average $7{\cdot}3\times3{\cdot}1\,\mu$; the appendage measuring $6{\cdot}4\times4{\cdot}8\,\mu$ ($3{\cdot}0 - 7{\cdot}2\times2{\cdot}0 - 6{\cdot}4$) average $6{\cdot}2\times4{\cdot}5\,\mu$.

The distinctive feature of the fungus is the membranous appendage of the conidium. The fungus bears some resemblance to *Koorchaloma madreeya* Subramanian (1953) in having the brush-like appendage of the spore, but differs from it in having no setæ in the sporodochium and in having irregularly ramose conidiophores. Therefore, a new

Table showing measurements of conidia, appendage and conidiophores of different isolates of Starkeyomyces

Herb M.U.B.L. No.	Conidium		Appendage		Conidiophore	
	Mostly (Range)	Average in μ	Mostly (Range)	Average in μ	Mostly (Range)	Average in μ
1390	7·2×3·4 (3·8–11·8×2·0–4·2)	7·3×3·1	6·4×4·8 (3·0–7·2×2·0–6·4)	6·2×4·5	7·2×2·4 (6·4– 9·6×2·0–3·2)	6·9×2·1
1391	7·8×3·2 (4·0–12·2×2·0–3·8)	7·6×3·1	7·2×6·4 (4·0–7·6×2·4–7·0)	6·9×5·9	9·6×2·8 (4·8–11·2×1·6–3·2)	9·2×2·5
1392	8·0×3·2 (4·0–12·0×1·6–4·0)	7·8×3·0	6·4×6·0 (2·8–8·0×2·0–7·0)	6·3×6·0	11·2×3·2 (7·2–14·0×1·6–3·6)	10·9×3·9
1393	8·1×3·4 (4·0–12·6×2·0–4·4)	7·8×3·2	7·2×6·8 (4·8–8·0×2·8–7·2)	6·8×6·4	8·0×3·2 (5·0– 9·6×2·0–3·2)	7·6×3·0
1394	7·8×4·0 (3·6–12·8×2·0–4·6)	7·6×3·8	5·6×4·8 (2·8–6·4×2·0–6·4)	5·3×4·6	9·6×2·8 (6·4–10·2×2·0–2·8)	9·5×2·6
1395	7·2×3·8 (3·4–12·0×2·0–4·8)	7·0×3·6	7·6×6·0 (3·2–8·0×1·6–6·4)	7·3×5·8	10·4×3·2 (5·2–11·0×1·6–3·2)	10·3×3·0
1396	8·0×4·0 (4·0–12·4×2·0–4·4)	7·8×3·8	6·0×5·6 (4·0–8·0×1·6–7·2)	5·8×5·3	8·0×2·8 (7·2– 9·6×2·0–3·2)	7·8×2·6
1397	8·4×4·0 (4·4–12·8×2·0–4·4)	8·1×3·9	6·8×6·8 (3·6–7·2×2·4–7·6)	6·5×6·3	10·8×3·2 (4·8–14·0×1·6–3·6)	10·5×3·1

genus is proposed to accommodate this fungus. The generic name is given in honour of Professor Dr. R. L. Starkey of the New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, New Jersey (U.S.A.), whose contributions to the rhizosphere microbiology are well known to soil microbiologists.

Starkeyomyces Agnihothrudu gen. nov.

Pertinet ad Fungos Imperfectos, ad Tuberculariaceas, Hyalosporas. Sporodochi lucide colorata, superficialia, integra. Conidiophori irregulariter ramosi, efformantes seriem hymenialem. Conidia hyalina, continua, acrogena, haud catenata, ornata appendice membranacea apicali. Species typica sequens.

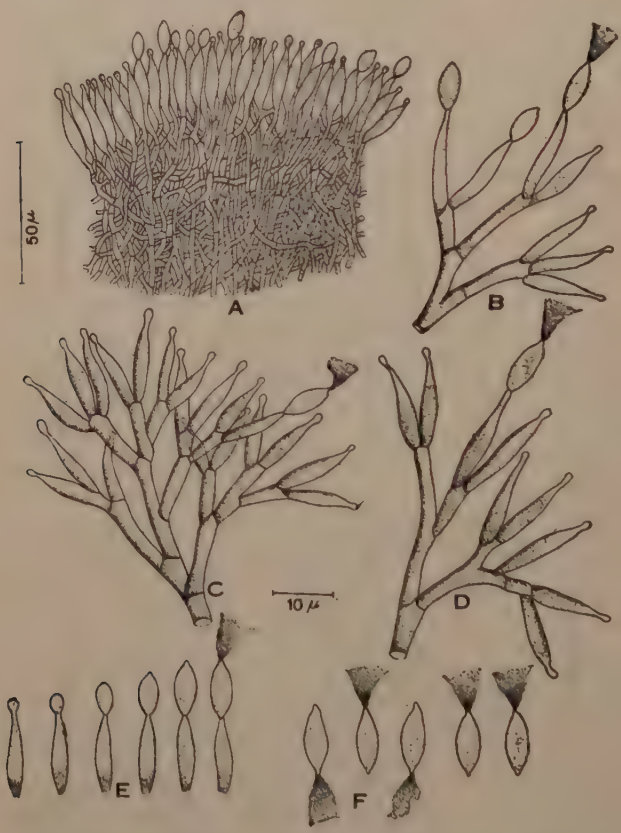

FIG. 1. *Starkeyomyces koorchalomoides* Agnihothrudu (Type, Herb. M.U.B.L. No. 1390). A. Section through a sporodochium. B, C and D. Irregularly branched conidiophores. E. Development of conidia. F. Mature conidia with appendage.

Starkeyomyces koorchalomoides Agnihothrudu sp. nov.—Sporodochia abundanter producta in mediis plurimis in laboratorio, alte

viridia colore, separata vel coalescentia, superficialia, integra, circularia vel irregularia ambitu, usque ad 3 mm. diameter atque 100 μ alta. Mycelium sterile dense intertextum, producens irregulariter ramosos conidiophoros, quorum ultimi ramuli arcte juxtapositi efformant seriem hymenialem uniformem. Conidia hyalina, semel cellulata, acrogena, solitaria, haud catenata, navicularia vel fusiformi- elliptica tenuia atque levibus parietibus prædita, tenuiter apiculata in utroque apice, magnit. $7{\cdot}2\times3{\cdot}4\,\mu$ ($3{\cdot}8$–$11{\cdot}8\times2{\cdot}0$–$4{\cdot}2$), mediatate $7{\cdot}3\times3{\cdot}1\,\mu$, quorum singula appendice membranacea apicali prædita atque magnit. $6{\cdot}4\times4{\cdot}8\,\mu$ ($3{\cdot}0$–$7{\cdot}2\times2{\cdot}0$–$6{\cdot}4$) medietate $6{\cdot}2\times4{\cdot}5\,\mu$.

Typica cultura segregata e rhizosphæra *Cajani cajan* (Linn.) Millsp. in humo naturaliter infecto a *Fusario udo* Butler, in campo laboratorii botanici universitatis, in urbe Madras, a V. Agnihothrudu, die 4 aprilis 1953 et positus in M.U.B.L. sub-numero.

Starkeyomyces Agnihothrudu gen. nov.

Fungus imperfectus, Tuberculariaceæ, hyalosporæ. Sporodochia bright coloured, superficial, entire. Conidiophores irregularly ramose, forming a hymenial layer. Conidia hyaline, continuous, acrogenous, non-catenate, with an apical membranous appendage.

Starkeyomyces koorchalomoides Agnihothrudu sp. nov.—Sporodochia produced abundantly on many laboratory media, deep green in colour, separate or coalescing, superficial, entire circular or irregular in outline up to 3 mm. in diameter and 100 μ tall. Sterile mycelium thickly interwoven, producing irregularly ramose conidiophores the ultimate branches of which are closely juxtaposed to form a uniform hymenial layer. Conidia hyaline, one-celled, acrogenous, solitary, non-catenate, naviculiform or fusiform-elliptic, thin and smooth-walled, slightly apiculate at either end, measuring $7{\cdot}2\times3{\cdot}4$ ($3{\cdot}8$–$11{\cdot}8\times2{\cdot}0$–$4{\cdot}2$) average $7{\cdot}3\times3{\cdot}1\,\mu$, each with a membranous appendage at the apex measuring $6{\cdot}4\times4{\cdot}8\,\mu$ ($3{\cdot}0$–$7{\cdot}2\times2{\cdot}0$–$6{\cdot}4$) average $6{\cdot}2\times4{\cdot}5\,\mu$.

Type culture isolated from the rhizosphere of pigeonpea [*Cajanus cajan* (Linn.) Millsp.] growing in soil naturally infested with *Fusarium udum* Butler, University Botany Laboratory campus, Madras, isolated by V. Agnihothrudu, 4th April 1953, Herb. M.U.B.L. No. 1390.

The following are other collections of the same fungus deposited in the Herbarium of Madras University Botany Laboratory. Soil from scrub jungle, Mount Abu (Bombay), coll. V. V. Krishnamurti on 2–6–1955, isolated on 15–6–1955, Herb. M.U.B.L. No. 1391, Kitchen Garden soil from Ahmedabad (Gujerat—Bombay), coll. V. V. Krishnamurti on 5–7–1955, isolated on 22–7–1955, Herb. M.U.B.L. No. 1392.

Rhizosphere soil of *Naregamia alata* W. & A. from Nilambur (Malabar-Madras), coll. V. Agnihothrudu on 12–5–1955, isolated on 20–5–1955, Herb. M.U.B.L. No. 1393. Rhizosphere soil of *Sphæranthus indicus* L. from Guruvayyur (Malabar-Madras), coll. V. Agnihothrudu on 8–5–1955, isolated on 23–5–1955, Herb. M.U.B.L. No. 1394.

Rhizosphere soil of seedlings of *Tectona grandis* L.f. from Topslip, Anamalais (Coimbatore-Madras), coll. V. Agnihothrudu, on 10–5–1955 isolated on 27–5–1955, Herb. M.U.B.L. No. 1395. Rhizosphere soil of *Nicotiana tabacam* L. from Vijayawada (Andhra), coll. V. Agnihothrudu on 9–12–1954, isolated on 1–1–1955, Herb. M.U.B.L. No. 1396. Garden soil from Bangalore (Mysore), coll. P. D. Varadarajan on 20–4–1955, isolated on 20–5–1955, Herb. M.U.B.L. No. 1397.

Acknowledgements

The author is grateful to Professor Dr. T. S. Sadasivan, Director, University Botany Laboratory, Madras, for his encouragement and to Dr. C. V. Subramanian, for his suggestions and criticism in the preparation of this paper. He is also thankful to Rev. Fr. Dr. H. Santapau, for the Latin diagnosis, to Drs. V. V. Krishnamurti and P. D. Varadarajan, for samples of soils from Bombay and Mysore States respectively and to the Government of India for the award of a fellowship during the tenure of which most of this work was done.

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HITHERTO UNREPORTED HOSTS OF *DENDROPHTHŒ FALCATA* (L. F.) ETTINGS

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(Received for publication on August 8, 1955)

Dendrophthœ falcata is reported to parasitise a large number of dicotyledons and some gymnosperms. Recently the author (Singh, 1954) recorded 34 new hosts of this parasite and pointed out that earlier workers (Fischer, 1926; Srivastava, 1935; Sayeedud-Din and Salam, 1935; and Ezekiel, 1935) had already reported 157 other hosts. Mathur's (1949) record of two more hosts escaped the author's notice at that time.

Recent collections made from the forests of Dehra Dun and Saharanpur districts (including the Fruit Research Station), under the scheme 'Control and ultimate eradication of Bandha parasite in Uttar Pradesh', show 53 additional hosts. The total number of different species attacked by *Dendrophthœ falcata* has thus gone upto 246 indicating that the infection is on the increase. It is high time that the Government takes up a regular survey of the parasite to obtain a statistical data showing the damage caused to economically important plants.

The following list gives the names of newly recorded hosts, the intensity of infection, as well as their economic importance.

Abbreviations for intensity of infection: H, heavy; M, moderate; S, slight; V, very heavy; and for economic uses of hosts: D, dye; F, fruit trees; G, gum; Me, medicinal; T, timber; O, ornamental.

Supplementary list of new hosts of *Dendrophthœ falcata* (L.f.) Ettings.

No.	Family and name of host plant	Type of infection	Economic use of host plant
	Magnoliaceæ		
1	*Magnolia grandiflora* L. ..	S	O
	Anonaceæ		
2	*Miliusa velutina* Hk. F. & T. ..	V	T
	Capparidaceæ		
3	*Cratæva religiosa* Forst ..	H	Me, T

No.	Family and name of host plant	Type of infection	Economic use of host plant
	Guttiferæ		
4	*Garcinia xanthochymus* Hk. F. ..	S	F, G, O, Me, T
	Malvaceæ		
5	*Kydia calycina* Roxb. ..	M	Me, T
	Sterculiaceæ		
6	*Heritiera minor* Roxb. ..	V	D, T
7	*Sterculia alata* Roxb. ..	S	O, T
	Tiliaceæ		
8	*Grewia elastica* Royle ..	V	F, T
9	*Grewia oppositifolia* Roxb. ..	H	D, T
	Rutaceæ		
10	*Limonia acidissima* Linn. ..	M	T
11	*Murraya exotica* Linn. ..	S	Me, O
12	*Toddalia aculeata* Pers. ..	V	D, Me
	Sapindaceæ		
13	*Litchi chinensis* Sonner ..	S	F
14	*Litsæa chinensis* Lam. ..	M	T
15	*Litsæa polyantha* Juss. ..	V	Me, T
	Leguminosæ Papilionaceæ		
16	*Cassia nodosa* Ham. ..	M	O
17	*Cassia siamea* Lam. ..	M	O, T
18	*Desmodium gangeticum* DC ..	S	Me
19	*Millettia tetraptera* Kurz. ..	M	O, T
	Cæsalpiniaceæ		
20	*Bauhinia purpurea* Linn. ..	V	Me, T
21	*Bauhinia retusa* Ham. ..	V	G, Me
	Mimosaceæ		
22	*Acacia farnesiana* Wild. ..	M	G, Me
23	*Albizzia odoratissima* Benth. ..	V	G, Me, T
	Combretaceæ		
24	*Anogeissus acuminata* Wall. ..	M	T
25	*Anogeissus pendula* Edgew. ..	V	T

No.	Family and name of host plant	Type of infec. tion	Economic use of host plant
	Lythraceæ		
26	*Lagerstræmia parviflora* Roxb.	M	G, O, T
27	*Lagerstræmia apeciosa* Pers.	S	O, T
28	*Woodfordia floribunda* Salisb.	M	D, G, Me
	Samydaceæ		
29	*Cæsaria tomentosa* Roxb.	H	Me, T
	Rubiaceæ		
30	*Hymenodictyon excelsum* Wall	M	F, Me, T
	Sapotaceæ		
31	*Chrysophyllum olivæforme* Lam.	V	F, T
	Ebenaceæ		
32	*Diospyros kaki* Linn.	M	F
33	*Diospyros montana* Roxb.	H	Me, T
34	*Diospyros tomentosa* Roxb.	M	F, Me, T
	Oleaceæ		
35	*Nyctanthes arbor-tristis* Linn.	M	D, Me, O, T
36	*Olea cuspidata* Wall	H	Me, O, T
	Boraginaceæ		
37	*Cordia obliqua* Willd	V	Me, T
38	*Cordia vestita* Hk. F. & T.	S	Me, T
	Bignoniaceæ		
39	*Kigelia pinnata* DC	S	O
40	*Stereospermum suaveolens* DC	V	G, Me, O, T
41	*Tecomella undulata* Seem.	H	G, Me, O, T
	Verbinaceæ		
42	*Gmelina arborea* Linn.	M	F, Me, T
43	*Tectona hamiltoniana* Wall.	V	T
	Euphorbiaceæ		
44	*Sapium sebiferum* Roxb.	M	D, Me, T
	Urticaceæ		
45	*Celtis australis* Linn.	H	Me, T
46	*Ficus altissima* Bl.	M	T

No.	Family and name of host plant	Type of infection	Economic use of host plant
47	*Ficus palmata* Forsk. ..	M	F, Me, T
48	*Ficus rumphii* Bl. ..	S	F, Me, T
49	*Holoptelia himalayans* DC ..	M	Me
50	*Holoptelia integrifolia* Planch. ..	H	Me, T
51	*Morus alba* Linn. ..	V	F, Me
52	*Sterbulus asper* Lour. ..	S	Me
	Salicaceæ		
53	*Salix acmophylla* Boiss. ..	M	Me, T

Acknowledgments

My thanks are due to Sri. J. N. Seth, Research Assistant and Sri. Kalu Ram, Specimen Collector, for the collection of the above hosts and to Mr. M. B. Raizada for identification of *Chrysophyllum olivæforme* Lam.

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SOIL CONDITIONS AND ROOT DISEASES

XVI. Colonization and Survival of *Macrophomina phaseoli* (Maubl.) Ashby in Trace Element Amended Soils*.

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(Received for publication on November 18, 1955)

Introduction

The beneficial role of trace elements in reducing infections by soil fungi has been, in recent years, a problem of keen interest. Evidence of zinc reducing the 'foot rot' of wheat was recorded by Millikan (1938) from Australia. Considerable check on the saprophytic activity of soil-borne Fusaria in trace element amended soils has been reported from this laboratory (Sarojini, 1950; Sulochana, 1952). So far there is no similar record regarding *Macrophomina phaseoli* (Maubl.) Ashby, the causative agent of cotton root rot. The following experiments were conducted to study the effect of certain trace elements on *M. phaseoli in vivo*.

Materials and Methods

Culture used.—A culture of *M. phaseoli* supplied by the Madras Government Mycologist, Coimbatore.

Soil used.—Root rot infested black cotton soil from Kovilpatti, Madras.

Colonization and survival of the fungus on cotton stubble.—Straw burial technique of Sadasivan (1939) as employed by Sarojini (1950) was adopted. Manganese, zinc and boron as manganese sulphate, zinc sulphate and boric acid were added to the soil in the form of solutions, the concentrations ranging from 2·5 to 80 mg. per 100 g. soil. After the required incubation period root pieces were surface-sterilized with calcium hypochlorite (Zachariah, 1953) and plated on Horne and Mitter's agar.

Experimental

Saprophytic activity of M. phaseoli *and trace element nutrition*

(1) *Survival.*—Effect of trace element amendment of the soil on the survival of *M. phaseoli* in artificially infected cotton root pieces buried in Kovilpatti soil was investigated. Manganese, zinc and boron at (i) 2·5, (ii) 5·0 and (iii) 10·0 mg. per 100 g. soil were added

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* Part of *Thesis* approved for the Degree of Doctor of Philosophy, University of Madras.

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to Kovilpatti soil and the viability of the fungus tested at regular intervals.

TABLE I

Showing percentage viability of M. phaseoli *in cotton stubble in Kovilpatti soil amended with trace elements Manganese, Zinc and Boron*

Treatments	Period of survival in weeks										
	4	8	12	16	20	24	30	36	42	48	52
BORON :											
I	100	100	100	100	100	100	100	100	95	80	60
II	100	100	100	100	100	100	100	100	100	95	70
III	100	100	100	100	100	100	100	100	100	80	45
MANGANESE :											
I	100	100	100	100	100	100	95	85	85	70	70
II	100	100	100	100	100	100	100	100	90	90	70
III	100	100	100	100	100	100	100	100	80	80	80
ZINC :											
I	100	100	100	100	100	100	100	100	85	80	75
II	100	100	100	100	100	100	100	100	95	95	85
III	100	100	100	100	100	100	100	100	80	80	70
CONTROL :	100	100	100	100	100	100	100	95	75	70	60

The results presented in Table I show that the survival of the fungus was not affected by trace elements amendments. During the period of observation *M. phaseoli* was recovered from 100 per cent. of the cotton stubble both from the trace element amended and unamended soil for fairly long periods; this survival period varied from approximately 24 weeks to 42 weeks in the various treatments.

(2) *Colonization.*—The colonizing capacity of the fungus on dead host material buried in black cotton soil with and without trace elements was next determined. Manganese, zinc and boron were added to soil at (i) 5, (ii) 10, and (iii) 20 mg. per 100 g. soil. The colonization of the fungus was ascertained at intervals of 4 or 6 weeks for 24 weeks. The results are presented in Table II.

Boron.—Boron at all concentrations failed to suppress colonization of *M. phaseoli* at the initial stage of incubation; however, it checked

TABLE II

Showing percentage colonization of M. phaseoli *on cotton stubble in Kovilpatti soil treated with trace elements, Manganese, Zinc and Boron*

Treatments		Period of incubation in weeks				
		4	8	12	18	24
BORON:	I	70	40	30	40	..
	II	80	50	30	20	..
	III	60	30	20	20	..
MANGANESE:	I	70	60	70	70	40
	II	50	60	60	60	50
	III	50	40	20	30	20
ZINC:	I	60	30	20	10	..
	II	40	20	30	30	20
	III	40	30	25	35	15
CONTROL:		80	70	40	25	10

colonization on long incubation and after 24 weeks there was no colonization.

Manganese.—Application of manganese at 2·5 mg. per 100 g. soil favoured the colonization of the fungus throughout the experimental period. At the higher concentrations fungal colonization was inhibited at the early incubation period, *i.e.*, 4 and 8 weeks and later on colonization was favoured.

Zinc.—All concentrations of zinc depressed *M. phaseoli* colonization; nevertheless this effect was less pronounced on longer incubation at 5 and 10 mg. per 100 g. soil applications.

Effect of trace elements on the general soil flora

M. phaseoli once it established itself in the host tissue buried in soil was able to survive for a considerable period immaterial of the trace element applications to the soil. Indeed, the same soil treatments inhibited the colonization of *M. phaseoli* on dead host tissue, although it is a dominant colonizer of dead plant material freshly introduced into the soil. The saprophytic phase of a soil fungus is determined not only by its cellulose decomposing power and the nutrient supply but is also dependent on its capacity to survive microbial antagon-

ism. How far the general microflora is stimulated by the trace element amendment of the soil was next studied.

Kovilpatti cotton soil was amended with manganese, zinc and boron and incubated at 50 per cent. of the water-holding capacity of the soil. After an incubation period of one month the fungi, bacteria and actinomycetes of these soils were quantitatively estimated by the dilution method of Waksman (1922). Levels of trace element applications were (i) 5 mg., (ii) 10 mg., (iii) 20 mg., (iv) 40 mg. and (v) 80 mg. per 100 g. soil. The results are presented in Table III.

TABLE III

Showing fungal, bacterial and actinomycetes numbers in Kovilpatti soil after 1 month's incubation with trace elements per g. of air-dry soil

Treatments	Rate of application in 100 g. soil	Fungi in thousands				Bacteria in millions	Actinomycetes in millions
		Aspergilli	Penicillia	Other fungi	Total		
BORON : ..	I	1000	100	362	1462	1·275	0·350
	II	650	50	275	975	1·8	0·325
	III	425	150	200	775	1·875	0·3
	IV	400	75	225	700	2·1	0·366
	V	225	25	225	475	2·275	0·425
MANGANESE :	I	725	162	137	1024	2·912	0·5125
	II	737	212	50	999	2·512	0·9
	III	700	250	50	1000	3·525	1·0
	IV	612	237	50	899	3·1375	1·0125
	V	500	287	50	837	3·067	0·7625
ZINC : ..	I	1187	537	150	1874	5·1	0·625
	II	1375	350	200	1925	4·9	0·85
	III	1012	387	112	1511	4·94	0·685
	IV	1025	300	162	1487	2·6	0·6
	V	1085	237	137	1459	2·9	0·2
CONTROL ..		500	118	150	768	2·175	0·425

Fungi.—Trace element amendments of the soil increased its fungal population, the lower concentrations of the elements, levels I and II

being more favourable, with increase in the concentration of the trace elements, a corresponding decrease in the fungal flora was recorded; nevertheless, considerable variation in the response of the soil fungi to the different trace elements existed. The fungi responded best to zinc and least to boron. Further, boron at level V depressed the fungal flora, whereas zinc at the same concentration stimulated it.

Actinomycetes.—All the concentrations of boron applied to the soil decreased actinomycetes while all levels of manganese and levels I, II, III and IV of zinc increased it, manganese being more effective than zinc. Highest concentration of zinc (level V) inhibited actinomycetes population.

Bacteria.—Soil bacteria were depressed by boron amendment of the soil although an increase in boron supply increased the bacterial flora. Manganese at all concentrations and zinc at levels I, II and III stimulated the soil bacteria. Zinc at levels IV and V inhibited the bacterial population.

Discussion

Sarojini (1950) demonstrated significant control of the survival and colonization of *Fusarium udum* by trace element amendments of the soil. Sulochana (1952) was able to correlate the saprophytic activity of *Fusarium vasinfectum* with the biological status of the soil treated with several trace elements. In the present investigation, boron, manganese and zinc supplied to Kovilpatti soil increased the soil microflora (Table III). However, the same treatments were able to control only the colonization of *M. phaseoli* on cotton stubble; the survival of the fungus was not affected by any of the soil treatments (Table I and II). This observation is justified by the fact that for colonization *M. phaseoli* is dependent on its hyphal growth which is susceptible to microbial antagonism, whereas the survival of the fungus for considerably long periods is rendered possible by means of its refractive sclerotia.

Summary

The response of *M. phaseoli* to trace element addition was studied *in vivo*. Survival of *M. phaseoli* in infected host tissue was not affected by boron, manganese and zinc amendment of the soil. Colonization of *M. phaseoli* on dead host material was inhibited by boron and zinc amendments on long incubation of the soil. Manganese, zinc and boron favoured the increase of the general soil microflora.

Acknowledgements

I have great pleasure in expressing my indebtedness to Prof. T. S. Sadasivan, for the valuable guidance and criticisms throughout the course of this work. I am grateful to the Government of India, for the award of a Junior Research Fellowship during the tenure of which this work was carried out.

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HYPHOMYCETES—I

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(Received for publication on November 28, 1955)

In this series of papers on Hyphomycetes I propose to record, describe or discuss hyphomycetes in general, with special reference to those occurring in India.

1. **Annellophora indica** sp. nov.

The fungus forms well-defined brownish-black colonies on living leaves of *Photinia* sp. and each colony consists of a cluster of conidiophores arising from a pale brown stroma. The stromatic hyphæ are brown in colour, septate and mostly 3·4–4·3 μ thick. The conidiophores arise laterally from cells of the repent hyphæ of the stroma and are erect, straight or bent, simple, dark brown in colour, thick-walled, up to 4-septate, somewhat cylindrical, slightly paler and narrower towards the tip, 54–100 μ long, 6·8–7·7 μ broad at the base, 5·9–7·7 μ broad in the middle and 3·4–6·0 μ broad at the tip. The conidiophore septa are largely confined to the basal part of the conidiophore and the distance between septa varies from 10–50 μ. The most striking feature of the conidiophore is the presence of numerous circular ridges or annellations towards the upper part of the conidiophore indicating where dispersal of conidia had occurred previously followed by successive proliferation of the conidiophores through the scars of fallen conidia to produce further terminal conidia. Up to 19 such annellations have been observed in a single conidiophore, the space between successive annellations varying from 2·5–4·3 μ. The conidia are pale golden brown in colour, smooth, two-celled, often with one or more guttules in one or both cells, with a flat base, a broader flask-shaped basal cell and a narrow tapering apical cell, 28–40 μ long, 3·4–4·3 μ broad at the flat base, 6·8–8·5 μ where it is broadest, 2·5–3·4 μ broad at the tip, and produced acrogenously and singly at the tips of the conidiophores.

The conidia of this fungus have a close resemblance to those of species of the genus *Passalora*, e.g., *P. bacilligera* (Mont. & Fr.) Mont. & Fr. and *P. depressa* (B. & Br.) Sacc., but conidial formation in my fungus is strikingly different. The peculiar annellations on the conidiophores suggest that it is best classified under *Annellophora* Hughes (Hughes, 1951 *a*), notwithstanding the fact that my fungus has two-celled conidia. I am, therefore, placing it under *Annellophora* and since it differs from species of this genus so far known, I am proposing a new species for it.

Annellophora indica Subramanian sp. nov.

Coloniæ in foliis viventibus brunneo-nigræ, constantes e fasciculis compactis conidiophororum qui exsurgunt e strato hypharum repentium.

Hyphæ repentes brunneæ, ramosæ, septatæ, 3·4–4·3 μ latæ. Conidiophori simplices, erecti, recti vel incurvi, fusce brunnei, crassis parietibus præditi, usque quater septati, aliquantum cylindrici, tenuiter angustiores atque pallidiores ad apicem, 54–100 μ longi, 6·8–7·7 μ ad basim, 5·9–7·7 μ ad medium, 3·4–6·0 μ ad apicem lati, annulati pluribus jugis vel annulis 2·5–4·3 μ inter se distantibus ad mediam vel plus quam mediam partem superiorem. Conidia pallide aureo-brunnea, bicellulata, levia, basi lata atque plana, cellula basali latiori urceolata, cellula apicali angustiori, 28–40 μ longa, 3·4–4·3 μ lata ad basim planam, 6·8–8·5 μ ad partem latissimam, 2·5–3·4 μ ad apicem, producta singula acrogene ad apices conidiophororum.

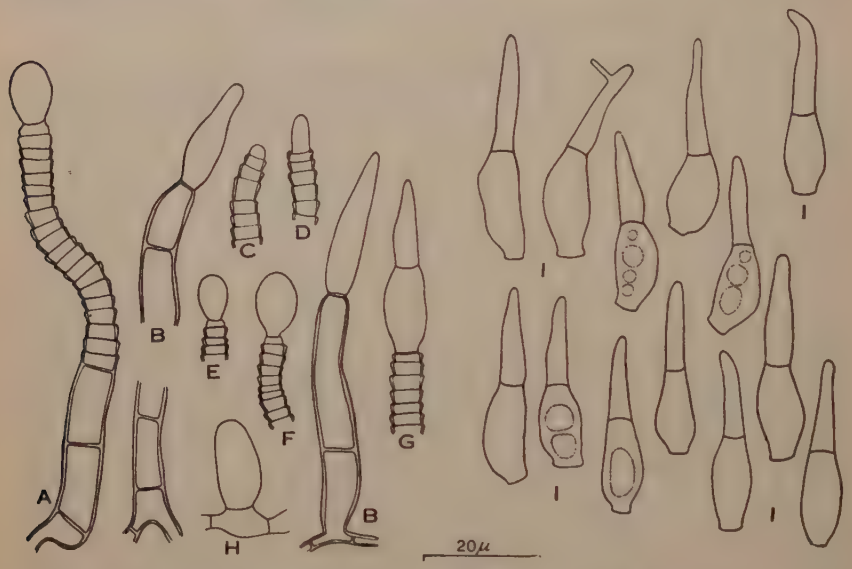

FIG. 1. *Annellophora indica* from type specimen, Herb. M.U.B.L. No. 1057. A–H, development of conidiophores and conidia; I, mature conidia.

Typus lectus in foliis viventibus *Photiniæ* cuiusdam speciei e familia Rosacearum, in loco Kodaikanal Hills, in dist. Madura, in Provincia Madras, die 12 decembris 1953, a K. Ramakrishnan et positus in herbario M.U.B.L. sub numero 1057.

2. **Excipularia narsapurensis** sp. nov.

This beautiful Tuberculariaceous fungus was collected by me recently from the Narsapur forests in the Hyderabad-Deccan and was found occurring on dead wood. The sporodochia are numerous and scattered on the substratum, entirely superficial, cup-shaped, black in colour, setose, 210–420 μ across and 98–140 μ tall excluding the setæ. The number of setæ per sporodochium is variable and up to 12 have been seen per sporodochium. The setæ are simple, brownish black to deep black, thick-walled, many- (up to 8-) septate, subulate, up to 280 μ long, up to 10·2 μ broad at the base, and up to 8·5 μ broad

in the middle. The conidiophores are short, simple, cylindrical, sub-hyaline and 3–5 μ broad. The conidia are dark brown, fusiform, 6–8-septate, constricted at the septa, and broadest and darkest in the middle. The penultimate cells at either end of the conidium are paler in colour than the middle cells, and the basal and apical cells are paler still, being sub-hyaline. The conidia are produced acrogenously and singly from the tips of the conidiophores. They are 61–73 μ long, 20·4–22·1 μ where they are broadest, 7·6–9·4 μ broad at the tip, and 5·1–8·5 μ broad at the base.

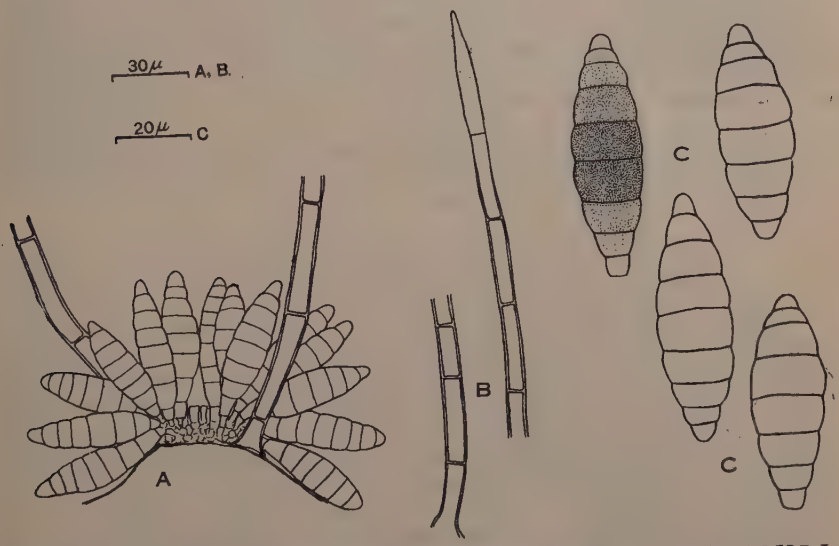

Fig. 2. *Excipularia narsapurensis* from type specimen, Herb. M.U.B.L. No. 1334. A, sporodochium showing setæ, conidiophores and conidia; B, seta; C, conidia.

This fungus belongs to the Tuberculariaceæ-Phæophragmeæ and is easily placed in the genus *Excipularia* Sacc. Two species of this genus are known, *viz.*, *E. fusispora* (B. & Br.) Sacc. [= *Excipula fusispora* B. & Br., 1859, in *Ann. nat. Hist.*, III, 359], the type species (Saccardo, 1884, p. 689) and *E. epidendri* P. Henn. (Hennings, 1905). The measurements of conidia, etc., in these two species are as follows:

	E. fusispora	*E. epidendri*
Sporodochia ..	70–120×70–120 μ	60–90 μ diam.
Setæ ..	60–90×3–4 μ	70–80×3–4 μ
Conidia ..	6–9-septate, 36–48×4–6·5 μ	3–4-septate, 12–30×4–5 μ

It is obvious that my fungus has much larger sporodochia, much onger setæ and much larger conidia than either of the above two pecies and I, therefore, propose to describe it as a new species.

Excipularia narsapurensis Subramanian sp. nov.

Sporodochia numerosa, dispersa in substratum, superficialia, nigra, cyathiformia, setosa, 210–420 μ diam., 98–140 μ alta (setis exclusis). Setæ usque duodenæ in singulis sporodochiis, simplices, brunneo-nigræ vel nigræ, crassis parietibus præditæ, pluriseptatæ (usque octies), subulatæ, usque ad 280 μ longæ, 10·2 μ latæ ad basim, 8·5 μ ad medium. Conidiophori breves, simplices, cylindrici, subhyalini, 3–5 μ lati. Conidia brunnea, fusiformia, 6–8-septata, constricta ad septa, 61–73 μ longa, 20·4–22·1 μ in parte latissima, 7·6–9·4 μ ad apicem, 5·1–8·5 μ ad basim, producta acrogene singula ad apices conidiophororum. Conidium latissimum atque coloris obscurioris ad medium; cellulæ penultimæ in utroque apice conidii pallidiores quam eae ad medium; cellulæ basales atque apicales utrinque pallidiores, *i.e.*, subhyalinæ.

Typus lectus in ligno quodam emortuo in loco Narsapur, in provincia Hyderabad-Deccan, die 22 augusti 1955 a C.V.S. et positus in herbario M.U.B.L. sub numero 1334.

3. *Exosporium arecæ* (B. & Br.) Petch, 1927, in *Ceylon J. Sci.* (*Ann. R. bot. Gdns Peradeniya*), **10**: 173–74.

The fungus forms black pulvinate colonies composed of closely aggregated conidiophores on the substratum, *viz.*, living leaves of *Areca catechu*. The conidiophores arise from a dark brown stromatic tissue composed of brownish black, branched, septate hyphæ which are 3–5 μ thick. The conidiophores are dark brown, simple, erect, straight or bent, cylindrical, septate and 224–504 μ long. The conidiophores are conspicuously verrucose and slightly thicker towards their tips than the rest of the conidiophore, being 10·2–13·5 μ wide at the tip; they are 7·6–9·4 μ wide below. The conidia are produced acrogenously and singly at the tips of conidiophores. They are obclavate, broadest at the second cell from the base, becoming progressively narrower above, 1–4-septate, constricted at the septa, dark brown, thick-walled, verrucose, 47·6–61·2 μ long, 18·7–22·1 μ where they are broadest, 3·4–9·4 μ broad at the tip and 3·4–5·1 μ broad at the point of attachment to the conidiophore. One or two of the cells immediately above the basal one of each conidium are the darkest, the other cells being paler in colour. This description is based on a study of Herb. M.U.B.L. No. 1388 (on living leaves of *Areca catechu*, Vittal, S. Kanara, Madras State, 28–8–1953, coll. T. S. Ramakrishnan). I have had occasion to examine the type specimen, *viz.*, Fungi of Ceylon, No. 833 sub. *Helminthosporium arecæ* B. & Br. on *Areca catechu* from Ceylon at the Commonwealth Mycological Institute, Kew (Herb. I.M.I. No. 7683 *ex* Herb. R.B.G., Kew). The conidia from the type measured 47–57 μ long and 20–23 μ thick where the conidia are broadest. I have been able to examine specimens pertaining to two other records of this fungus from India, *viz.*, on *Areca catechu*, Sirsi, Bombay, June 1913, coll. & det. G. S. Kulkarni (Herb. M.U.B.L. No. 813 *ex* Herb. Crypt. Ind. Orient. No. 12246) and on the same host, Assam, coll. J. N. Sen, November 1927 (Herb. M.U.B.L. No. 812 *ex* Herb. Crypt. Ind. Orient. No. 12248),

both collections being labelled "*Brachysporium arecæ* (B. & Br.) Sacc." Indeed, during my visit to the C.M.I., Kew, in 1950, I found I.M.I. 7683 referred to above disposed under *Brachysporium arecæ*.

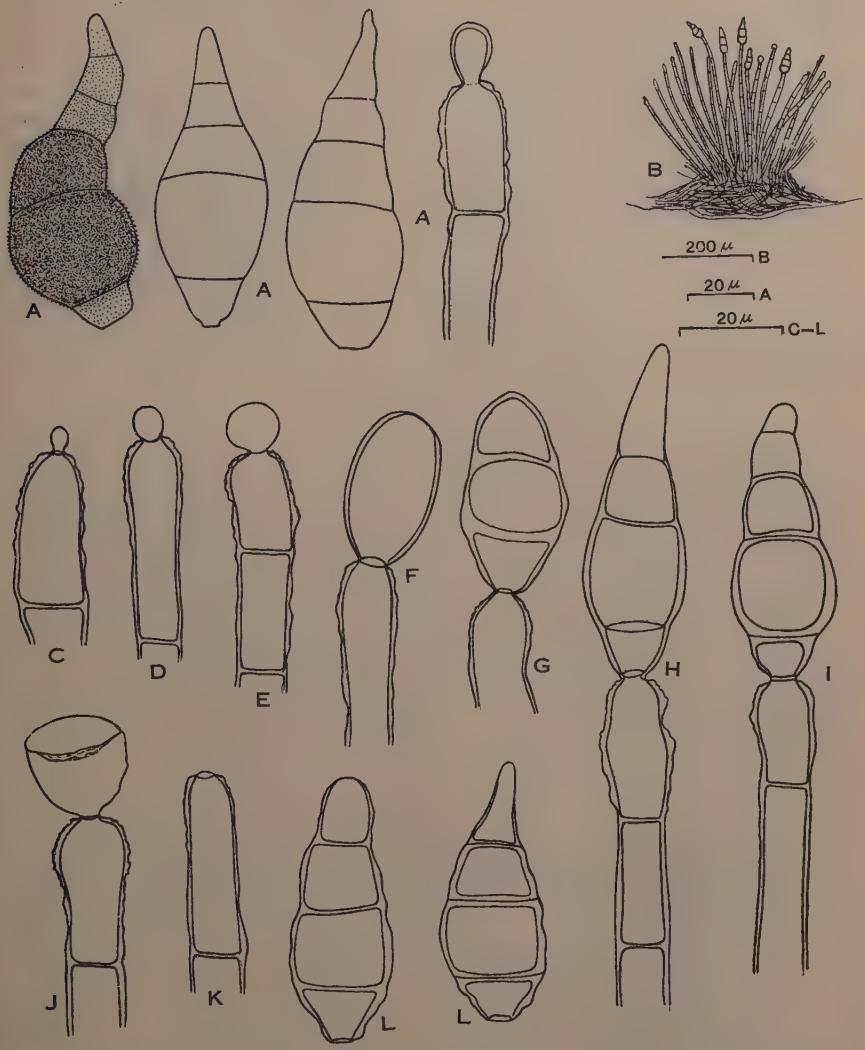

FIG. 3. *Exosporium arecæ*; A, showing three conidia and part of a conidiophore from type specimen, Herb. I.M.I. No. 7683; B–L, from Herb. M.U.B.L. No. 1388. B, a cluster of conidiophores; C–I, development of conidia; J–K, tips of conidiophores showing detachment of conidia; L, conidia.

After a study of the above specimens, which includes the type, I am in complete agreement with Petch's (1927) disposition of the fungus under *Exosporium*. It is not congeneric with *Brachysporium*

obovatum (Berk.) Sacc., the lectotype species of the generic name *Brachysporium* Sacc. (Hughes, 1951 *c*).

It would also appear that the fungus has received two other names in literature: *Exosporium pulchellum* Sacc. (Saccardo, 1931, p. 994–95) and *E. eximium* Sacc. (Saccardo, 1931, p. 994). *E. pulchellum* was described in 1916 (in Notæ Myc. XX, in *Nuovo G. bot. ital.*, V, **23**, p. 215) and was collected on decaying leaves of *Areca catechu* from the Philippines; and *E. eximium* was described in 1918 (in Notæ Mycol. XXIV, in *Bull. Orto bot. Napoli*, **1928**, p. 526), also on dead leaves of *Areca catechu*, collected from the botanical garden, Singapore. Comparative measurements of the sporodochia, etc., of these two species (from Saccardo, 1931, pp. 994–95) are given below:

	E. pulchellum	*E. eximium*
Sporodochia ..	Black, 500–700 μ diam.	Black, 400–500 μ diam.
Conidiophores ..	220–350 × 6–8 μ	300–350 × 7–9 μ
Conidia ..	3-septate, 48–50 × 16–16·5 μ	3–4-septate, 40 × 16 μ

The conidia of *E. eximium* were described as: "conidiis in quoque conidiophoro subquinis, obclavatis, basi tenuato-truncatis, sursum acutato-subcuspidatis, ... constrictis, ..., cellula ima minima subhyalina, secunda castaneo-atra, tertia dilute castanea, apicali subhyalina, episporio et conidiophoris lenissime asperulis." The description of the conidia of *E. pulchellum* was as follows: "conidiis breviter fusoideo oblongis, subrectis, apice obtuse tenuatis, basi longiuscule apiculatis, ..., ad septa leniter constrictis, levibus, ..., fuligineis, loculis binis centralibus saturatioribus." I have not seen specimens authentic for these names, but from the descriptions quoted above, the two species appear to me to be identical. Further, they appear to be identical with *Helminthosporium arecæ* B. & Br.

As a summary to the foregoing discussion, I give below a nomenclator:

Exosporium arecæ (B. & Br.) Petch, 1927, in *Ceylon J. Sci.* (*Ann. R. bot. Gdns Peradeniya*), **10**: 773–74; Ramakrishnan, T. S., & Sundaram, N. V., 1954, *Indian Phytopath.*, **7**: 64–65.

= *Helminthosporium arecæ* B. & Br., 1875, *J. Linn. Soc.* (*Bot.*), **14**: 98.

= *Brachysporium arecæ* (B. & Br.) Sacc., 1886, in *Sylloge Fungorum*, **4**: 429.

= *Exosporium pulchellum* Sacc., 1916, in Notæ Mycol. XX, *Nuovo G. bot. ital.*, V, **23**: 215; Saccardo, 1931, *Sylloge Fungorum*, **25**: 994.

= *Exosporium eximium* Sacc., 1918, in Notæ Mycol. XXIV, *Bull. Orto. bot Napoli*, 1918, p. 26; Saccardo, 1931, in *Sylloge Fungorum*, **25**: 994.

4. **Exosporium coonoorense** sp. nov.

This fungus was recently collected by me from the Nilgiris and was found to occur on dead stems surrounded by leaf litter in moist

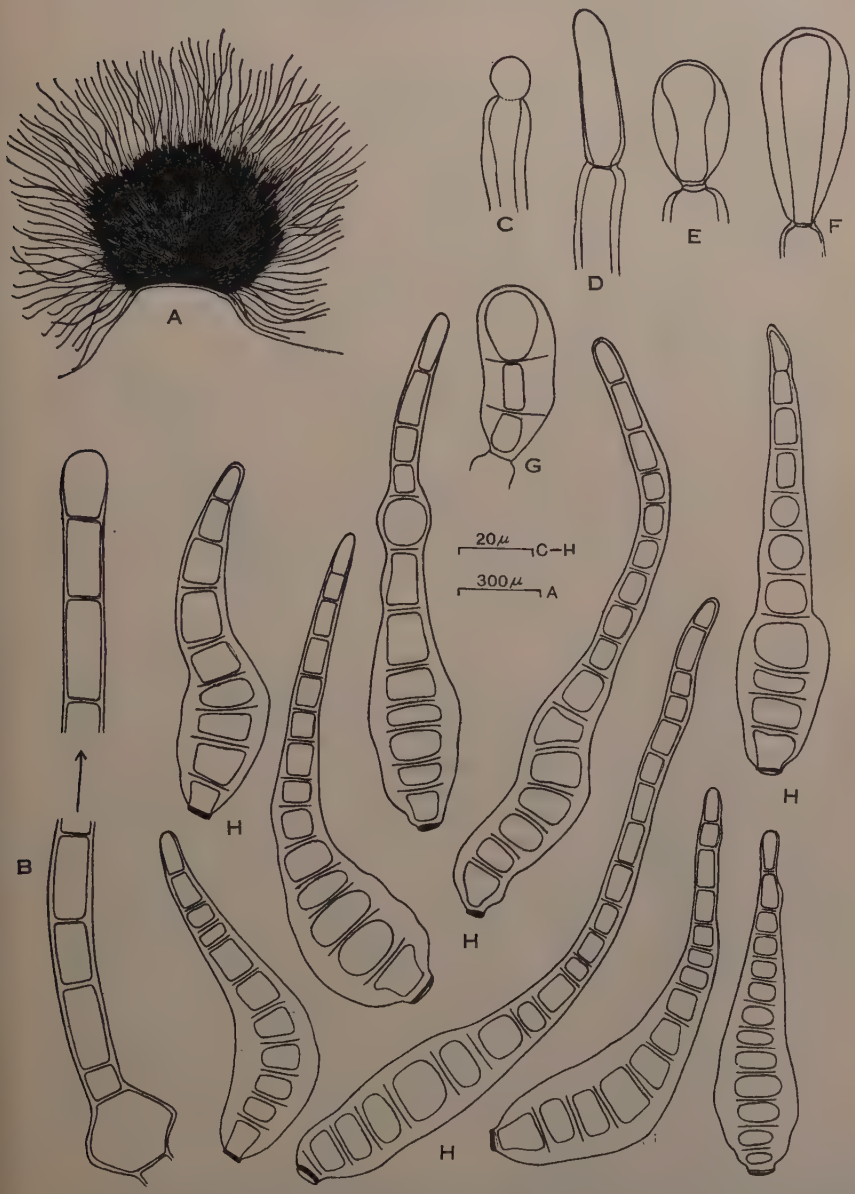

FIG. 4. *Exosporium coonoorense* from type specimen, Herb. M.U.B.L. No. 1336. A, a sporodochium; B, a single conidiophore; C–G, development of conidia; H, mature conidia.

situations. The colonies are black, consist of compact clusters of numerous conidiophores, and are up to 1120 μ across and up to 910 μ tall. The conidiophores arise from a cushion-like stromatic base. The conidiophores are simple, brown, somewhat cylindrical, erect, straight, bent or flexuous, thick-walled, up to 770 μ long, many-septate, with a swollen basal cell up to 25 $\times$ 25 μ in size, up to 12 μ thick immediately above the swollen basal cell, 12–14 μ thick in the middle, and 11–14 μ thick at the apex which is blunt and rounded. The conidiophores are darker in colour towards the base and paler above. The conidiophore septa are usually up to 42 μ apart or often less. The conidiophores sometimes have one or more swellings and these are about 18–22 μ thick. The conidia are produced singly and acrogenously at the tips of conidiophores. They are typically obclavate, broadest towards the base, becoming much narrower and tapering above, brown, verrucose, 10–20-septate, thick-walled, straight or often curved variously, 90–200 μ long, 22–27 (–33) μ where they are broadest and 5–7 μ broad at the apex. Each conidium has a prominent scar 5–8 μ broad at the base, indicating the point of attachment to the conidiophore. The tips of the conidia are hyaline to sub-hyaline and blunt and rounded. The conidia appear to be produced as blown out ends of conidiophores.

The simple conidiophores arising in clusters from a basal stroma and the production of phæophragmospores singly and acrogenously from the tips of conidiophores indicate that the fungus is an *Exosporium*. It appears to be distinct from species of this genus so far known and is therefore being classified as a new species.

Exosporium coonoorense Subramanian sp. nov.

Coloniæ atræ, constantes e fasciculis compactis plurium conidiophororum, usque ad 1120 μ diam., 910 μ altæ. Conidiophori surgentes e basi stromatica pulvinariformi, simplices, aliquantum cylindrici, erecti, recti, curvati vel flexuosi, brunnei, crassis parietibus prædíti, pluries septati, ornati cellula basali tumescente usque ad 25 μ crassa et alta, usque ad 12 μ crassi immediate supra cellulam basalem tumescentem, 12–14 μ crassi ad medium, 11–14 μ crassi ad apicem, obscurioris coloris ad basim, pallidiores supra, usque 770 μ longi; conidiophororum septa 42 μ inter se distantia vel proximiora. Conidia obclavata, latissima ad basim, evadentia multo angustiora atque fastigata supra, recta vel sæpe curvata varie, brunnea, crassis parietibus prædita, verrucosa, 10–20-septata, 90–200 μ longa, 22–27 (–33) μ lata ad partem latissimum, 5–7 μ lata ad apicem, singula ornata cicatrice basali prominenti 5–8 μ lata, producta singula acrogene ad apices conidiophororum.

Typus lectus in culmis emortuis in loco Sim's Park, ad Coonoor, in districtu Nilgiris, in provincia Madras, die 23 mensis septembris anno 1955, a C.V.S. et positus in herbario M.U.B.L. sub numero 1336.

5. **Helicoceras longisporum** sp. nov.

This fungus was collected on living leaves of *Celtis serotina* from the Nilgiris. The fungus forms chocolate brown epiphyllous effuse colonies on the living leaves. The repent hyphæ are sub-hyaline to

golden brown, branched, septate, and 1·7–5·1 μ thick. The conidiophores are short and arise laterally or apically from cells of the repent hyphæ. The conidiophores are short and somewhat globose, or elongated and sub-cylindrical, erect or decumbent, straight, bent or flexuous, 0–5-septate, 8·5–44·2 μ long and 5·9–7·7 μ broad. The short globose to sub-globose conidiophores are concolorous with the

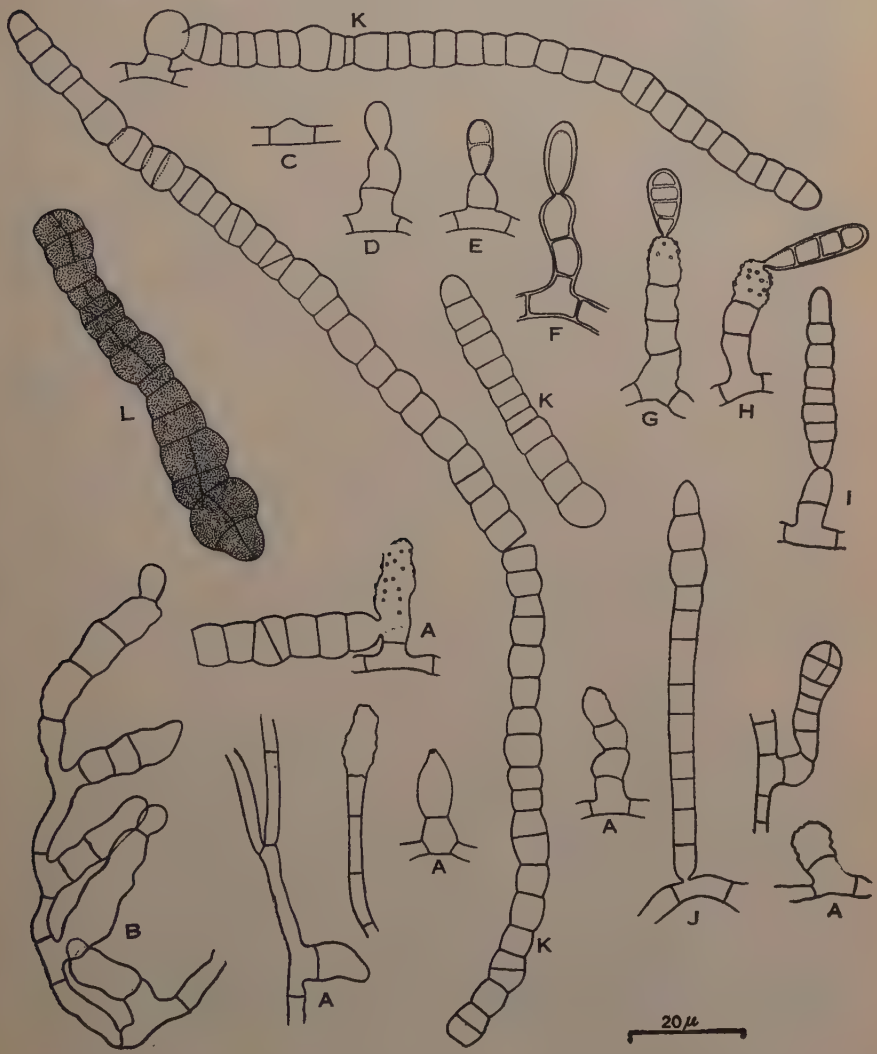

FIG. 5. *Helicoceras longisporum* from type specimen, Herb. M.U.B.L. No. 1382. A–B, conidiophores; C–I, development of conidiophores and conidia; J, production of one conidium laterally from a cell of a vegetative hypha; K, mature phragmospores; L, a mature dictyospore.

repent hyphæ. The elongate cylindric conidiophores are darker in colour, being brown, and have wavy and slightly verrucose walls. The conidia are borne acrogenously at the tips of the conidiophores or often from more than one point on the conidiophore. The conidia are long, brown in colour, somewhat cylindrical, often curved, many times transversely septate and constricted at the septa. The individual cells of the phragmo-conidia are mostly broader than longer, the distance between transverse septa of the conidia varying from 3·4–8·5 μ. One or more cells of the conidia may have diagonal or longitudinal septa. The conidia are 150–280 μ long, 6·8–12·0 μ thick where they are broadest and 5·1–9·4 μ broad elsewhere. In a few cases the conidia have been seen to be produced directly and laterally from cells of the repent hyphæ.

It will be clear from the above description that the fungus belongs to the genus *Helicoceras* Linder (Linder, 1931, pp. 2–3). The host genus on which the present fungus has been collected is the same as that on which the description of the type species is based, *viz.*, *Celtis*. The type species is *H. celtidis* (Biv.-Bernh.) Linder, and this species has been collected on a number of species of *Celtis*. On the basis of a study of several European and other specimens of this fungus, Linder (1931, p. 4) gave the following description for the fungus: "Mycelium light fuscous to fuscous, branched, septate, penetrating through the host tissues. Conidiophores as short branches of the mycelium, simple, little differentiated. Conidia fuscous, curved, circinate, or once coiled, more conspicuously coiled in dried material, multiseptate, some cells occasionally diagonally or longitudinally septate, constricted at the transverse septa, 50–100×5–8 μ, the cells shorter than wide." I had at first disposed my fungus under *H. celtidis*, but the conidia are mostly twice as long and slightly thicker than in *H. celtidis*. Indeed, the conidia in my fungus are much longer than those of the four species of *Helicoceras* so far known (see Moore, 1955) and my fungus is, therefore, described here as a new species.

Helicoceras longisporum Subramanian sp. nov.

Coloniæ epiphyllæ, badiæ, effusæ. Hyphæ repentes subhyalinæ vel aureo-brunneæ, ramosæ, septatæ, 1·7–5·1 μ crassæ. Conidiophori surgentes lateraliter vel terminaliter e cellulis hypharum repentium, breves, aliquantum subglobosi, atque eiusdem coloris ac hyphæ repentes, vel tenuiter elongati, subcylindrici atque pallide brunnei vel brunnei, erecti vel decumbentes, recti, curvati vel flexuosi, 0–5-septati, 8·5–44·2 μ longi, 5·9–7·7 μ lati. Conidia producta singula acrogene ad apices vel pleurogene ex una alterave parte conidiophori, brunnea, longa, aliquantum cylindrica, sæpe curvata vel flexa, sæpissime transverse septata, constricta ad septa, 150–280 μ longa, 6·8–12·0 μ ad partem latissimam, 5·1–9·4 μ lata alibi, cellulis nonnullis diagonaliter vel longitudinaliter septatis, cellulis omnibus latioribus quam longioribus.

Typus lectus in foliis viventibus *Celtis serotinæ* Pl. e familia Ulmacearum, in loco Sim's Park, in Coonoor, Dist. Nilgiris, in provincia Madras, die 25 septembris anni 1955, a C.V.S. et positus in herbario M.U.B.L. sub numero 1382.

Two other species of *Helicoceras* are known from India: *H. celtidis* (Thirumalachar and Lacy, 1951, as *Gyroceras celtidis*) and *H. oryzæ* Linder and Tullis (Ramakrishnan and Subramanian, 1952, p. 23).

6. **Helicomina indica** sp. nov.

This fungus was collected by me from Castle Rock in the Bombay State during a visit in 1954 and occurred on living leaves of an unidentified leguminous plant. The colonies on the leaves simulate sooty spots. The conidiophores are simple, erect, straight or bent, mostly 3- but up to 5-septate, somewhat cylindrical, brown in colour, darker towards the base and paler above, arising from a pale brown hypophyllous stroma, and occurring in compact clusters. The conidiophores have wavy walls towards the tips, are up to 144 μ long, 5·1–7·7 μ broad at the base, 3·4–6·0 μ broad in the middle and 4·2–6·0 μ broad at the tip. The conidia are sub-hyaline to pale brown in colour, straight, curved, bent or curled variously, usually up to 5-septate, cylindrical in the middle and becoming narrower towards either end, each with a somewhat mamillate base and a broadly or narrowly rounded smooth tip, smooth, produced singly and acrogenously at the tips of conidiophores, 20·4–57·8 × 5·7–10·2 μ. Some conidia have been found to have a button-like or somewhat elongated apical outgrowth.

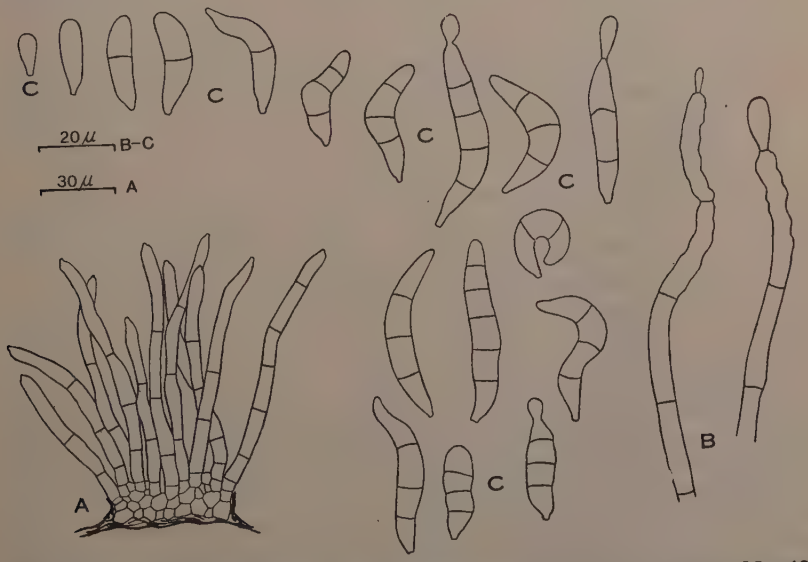

FIG. 6. *Helicomina indica* from type specimen, Herb. M.U.B.L. No. 1217. A, a cluster of conidiophores; B; conidiophores showing the production of conidia; C, conidia.

This fungus belongs to the Dematiaceæ-Phragmosporæ (Helicosporæ ?) and appears to possess the characteristics described by Olive (1948) for the genus *Helicomina*. This genus, so far as I am aware, is monotypic and the type species, *H. caperoniæ* Olive was collected

on living leaves of *Caperonia castanaefolia* (L.) St. Hil. (Euphorbiaceae) from Louisiana. The conidiophores of *H. caperoniæ* were described as 2–12-septate and 92–329×4–6·6 μ, and the conidia as 1–7-septate, mostly 3-septate, and 17·4–40×4·5–6·3 μ. My fungus has morphologically a close similarity to Olive's, but the conidia appear to be larger and I, therefore, consider it best to keep my fungus separate and am describing it as a new species.

Helicomina indica Subramanian sp. nov.

Coloniæ in foliis viventibus fuligineæ, constantes e fasciculis conidiophororum surgentium e stromate hypophyllo. Conidiophori simplices, erecti, recti vel incurvi, nonnihil cylindrici, marginibus undulatis ad apicem, usque quinquies septati, brunnei, obscurioris coloris ad basim, pallidiores supra, usque ad 144 μ longi, 5·1–7·7 μ ad basim, 3·4–6·0 μ ad medium, 4·2–6·0 μ ad apicem lati. Conidia subhyalina vel pallide brunnea, recta, incurva vel varie curvata, usque quinquies septata, cylindrica ad medium, fastigata ad utrumque apicem, singula ornata basi aliquantum mamillata atque apice anguste vel late rotundato, levia, producta singula acrogene ad apices conidiophororum, 20·4–57·8 ×5·7–10·2 μ.

Typus lectus in foliis viventibus plantæ cuiusdam e Leguminosis, in loco Castle Rock, in provincia Bombay, die 29 decembris 1954 a C.V.S. et positus in herbario M.U.B.L. sub numero 1217.

7. *Helminthosporium guareicola* Stevens, 1918 (March), in *Bot. Gaz.*, **65**: 241 (as 'guareicolum'); Saccardo, 1931, *Sylloge Fungorum*, **25**: 832; Hughes, S. J., 1953, *Mycol. Pap.*, **50**: 25–26.

   =*Helminthosporium flagellatum* Yates, 1918 (November), in *Philipp. J. Sci.*, **13**: 383; Saccardo, 1931, *Sylloge Fungorum*, **25**: 827.

   =*Helminthosporium spirotrichum* Saccardo, 1921, in *Boll. Orto bot. Napoli*, **6**: 61.; Saccardo, 1931, *Sylloge Fungorum*, **25**: 826.

This fungus is a hyperparasite and was recently collected on Meliolineæ on living leaves of an unidentified angiosperm from Castle Rock in the Bombay State. The conidiophores occur in closely aggregated clusters, and arise laterally from cells of the repent hyphæ. They are simple, erect, straight, bent or curved, somewhat cylindrical, dark brown in colour, thick-walled, many-septate, 240–532 μ long, 6·8–10·2 μ thick at the base, and up to 8·5 μ thick above. The most noteworthy feature of the conidiophore is its marked zigzag appearance when viewed from the side. The zigzag appearance is the result of successive production of conidia regularly to the left and to the right. As indicated by Hughes (1953), the conidiophores may occasionally produce 2–3 zigzag fertile portions, each separated by a short cylindrical region and the planes of the separated regions of geniculation may be different. The conidia are acrogenous and are produced singly at the

tip of the conidiophore. They are somewhat fusiform to obclavate, flat- and broad-based, broadest in the middle or nearer the base, becoming progressively narrower above, having tapering and smoothly

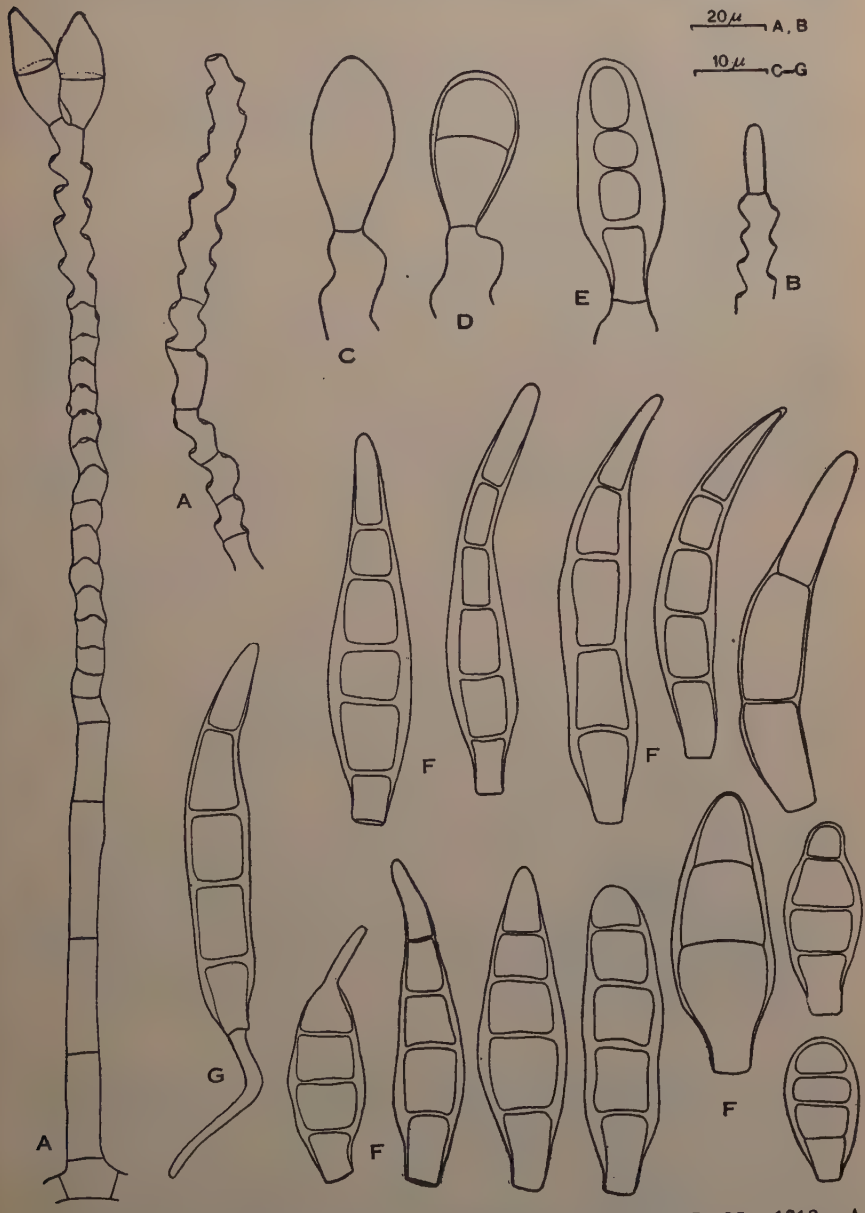

FIG. 7. *Helminthosporium guareicola* from Herb. M.U.B.L. No. 1218. A, conidiophores with conidia; B-E, development of conidia; F, mature conidia; G, germinating conidium.

rounded tips or bluntly rounded ends, thick-walled, golden to dark brown in colour, smooth-walled, usually 3–4- but up to 5-septate, and not constricted at the septa. They are 28·8–68·4 μ long, 4·2–6·0 μ broad at the base, 8·5–15·3 μ where they are broadest, and 2·5–6·8 μ broad at the tip. Conidial germination takes place through the apical or the basal cell.

Only one collection has been made: parasitic on Meliolineæ, occurring on living leaves of unidentified angiosperm, Castle Rock, (Bombay State), 29–12–1954, coll. K. Ramakrishnan, Herb. M.U.B.L. No. 1218.

8. **Lomachashaka kera** gen. et sp. nov.

The fungus forms scattered sporodochia which are waxy in appearance. They are superficial, light green in the centre with a white fringe, circular or oval in outline when viewed from above, cup-like when viewed from the sides, 210–350 μ across, and 80–100 μ tall. The white fringe characteristic of the sporodochia is composed of numerous unbranched, thin-walled, hyaline, septate,. erect, straight, bent or flexuose, sterile hairs, surrounding the central sporiferous part of the sporodochium. These sterile hairs may be up to 200 μ long and 1·6–2·5 μ thick throughout their length. The conidiophores arise from a stratum of hyaline, septate, vegetative hyphæ and form a closely arranged hymenium above. The conidiophores are hyaline,

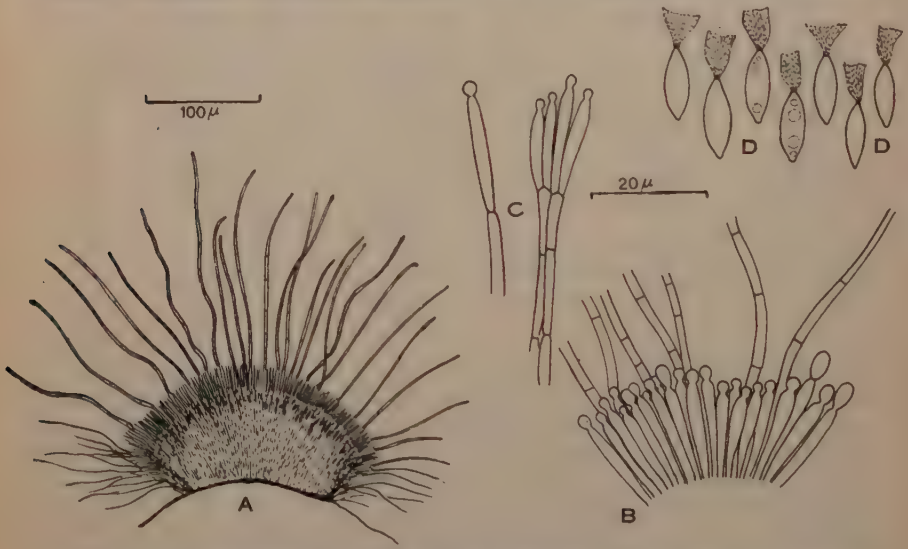

FIG. 8. *Lomachashaka kera* from type specimen, Herb. M.U.B.L. No. 955. A, a sporodochium; B,C, phialide-like tips of conidiophores; D, conidia.

thin-walled, cylindrical, and terminate in one or two phialides each. The phialides are 13–19 μ long and 1–3 μ broad. The conidia are produced acrogenously and singly from the tips of the phialides. They are fusiform with a mamillate base, one-celled, hyaline, each with two

to four guttules and an apical appendage. This appendage is brush-like, obconical in shape, mucoid, 4·9–6·6 μ tall, and 4·9–6·6 μ where it is broadest. The conidia are mostly 11·6×3·3 μ, but their size varies from 9–14×2–4 μ.

The most characteristic features of the fungus just described are: (i) the cup-like sporodochia fringed with numerous simple, hyaline, septate, sterile hairs and (ii) the one-celled conidia with the characteristic apical appendage. The conidia are very similar to those of *Koorchaloma madreeya* Subram. (Subramanian, 1953), but the present fungus differs from *K. madreeya* in having hyaline, thin-walled sterile *hairs* around the sporodochium instead of dark brown, thick-walled *setæ* which are typical of *K. madreeya*. It has also a close resemblance to *Starkeyomyces koorchalomoides* Agnihotrudu (Agnihotrudu, 1956); but the latter has sporodochia which lack setæ or hairs. I know of no genus of the Tuberculariaceæ in which my fungus may be placed. Accordingly, I am proposing a new genus to accommodate my fungus and am naming it *Lomachashaka kera*, the generic and specific names being derived from Sanskrit: the generic name from लोम (*lōma* = hair) and चषक (*chashaka* = cup), indicative of the cup-like sporodochium fringed by hairs; and the specific epithet from केर (*kera* = the coconut palm), from the host plant on which the fungus was collected.

Lomachashaka Subramanian gen nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Tuberculariaceas, Hyalosporas.

Sporodochia superficialia, cyathiformia, ciliata plurimis capillis simplicibus, septatis, hyalinis atque sterilibus. Conidiophori simplices, hyalini, cylindrici, septati, desinentes in phialides. Conidia hyalina, semel cellulata, singula ornata appendice apicali unica obconica evanescenti mucoidea, acrogene et singulariter producta ex apicibus phialidum.

Fungus imperfectus, Moniliales, Tuberculariaceæ, Hyalosporæ.

Sporodochia superficial, cup-like, fringed with numerous simple, septate, hyaline, sterile hairs. Conidiophores simple, hyaline, cylindrical, septate, terminating in phialides. Conidia hyaline, one-celled, each with a single apical, obconical, evanescent, mucoid appendage, produced acrogenously and singly from the tips of phialides.

Type species

Lomachashaka kera Subramanian sp. nov.

Sporodochia superficialia, pallide viridia in medio, albide fimbriata, circularia vel ovalia ambitu supra, cyathiformia, 210–350 μ diam., 80–100 μ alta; fimbriæ albidæ constantes ex plurimis capillis, qui sung simplices, hyalini, septati, parietibus tenuibus præditi, erecti, recti vel curvati vel flexi et steriles, dimetientes 200 μ longit. et 1·6–2·5 μ crassit. Conidiophori dense aggregati ad efformandum hymenium, surgentes e strato hypharum (quæ sunt hyalinæ, septatæ atque vegetativæ), hyalini, simplices, tenuibus parietibus præditi, cylindrici, septati,

desinentes in unam duasve phialides; phialides vero 13–19 μ longæ, 1–3 μ latæ. Conidia producta acrogene atque singulariter ad apices phialidum, hyalina, in massa pallide viridia, fusiformia, basi mamillata, semel cellulata, singula ornata duplici vel quadruplici guttula atque appendice apicali, 11·6×3·3 (9–14×2–4 μ). Appendix mucoidea, evanescens, obconica, 4·9–6·6 μ alta, 4 9–6·6 μ lata ad partem latissimam.

Typus lectus in foliis emortuis *Cocos nuciferæ* Linn. in campo Laboratorii Botanici Universitatis die 28 mensis octobris anni 1953 a C.V.S. et positus in herbario M.U.B.L. sub numero 955.

9. **Paathramaya sundara** gen. et sp. nov.

This interesting stilbaceous fungus was recently collected by me from the Narsapur forests in the Hyderabad (Deccan) State, and was found growing on dead stems. The fungus forms numerous scattered, dark to blackish-brown synnemata, each with a fan-shaped, sub- or hemi-spherical or irregularly globose capitate head consisting of closely aggregated free ends of conidiophores and conidia produced on them. Each synnema has an erect stalk composed of numerous, closely parallel, unbranched, septate, sub-hyaline to pale brown hyphæ which appear dark in mass. The stalk of each synnema is sub-cylindrical, 360–750 μ long, 112–280 (–532) μ thick at the base, 35–140 (–322) μ thick in the middle, and 84–182 (–420) μ thick immediately below the head. The head is concolorous with the stalk, is fan-shaped in relatively young fructifications, but somewhat hemispherical or irregularly sub-globose when mature, and consists of closely aggregated free ends of conidiophores. The heads are 266–532 (–1260) μ across and 168–280 (–700) μ tall. The conidiophores are unbranched, few-septate, sub-hyaline individually but brownish in mass, non-septate in the upper part which alone is fertile, thick-walled with wavy margins, somewhat cylindrical, of variable length, the length of the fertile part being up to 210 μ, 10·2–13·6 μ broad in the fertile region, and up to 6·8 μ broad below. Each conidiophore terminates in a conspicuous cup-like protuberance subtended by a constriction and has also many (up to about 20 per conidiophore) similar cup-like protuberances arising from scattered points laterally all over the fertile part of the conidiophores. The acrogenous and pleurogenous cup-like structures are concolorous with the conidiophore; the former measure 6·8–8·5 ×5·1–6·8 μ and the latter 5·1–8·5×5·1–8·5 μ. The conidia are produced singly at the tips of the acrogenous and pleurogenous cup-like protuberances. The conidia are one-celled, dark brown, oval in shape, almost always with a prominent guttule, smooth and thick-walled, non-catenate, and 20–29×17–21 μ.

The acrogenous and pleurogenous cup-like structures produced on the conidiophores and the production of smooth phæospores singly from the tips of these cup-like structures are the most noteworthy features of the fungus just described and, as far as I am aware, this has not been described for any genus of the Stilbaceæ-Phæosporæ so far known. The genus *Basidiella* Cooke has been considered as a repository for my fungus; but the type species *B. sphærocarpa* was

described (Cooke, 1878) as producing roughened phæospores singly at the tips of minute spicules on the conidiophores. I, therefore, propose

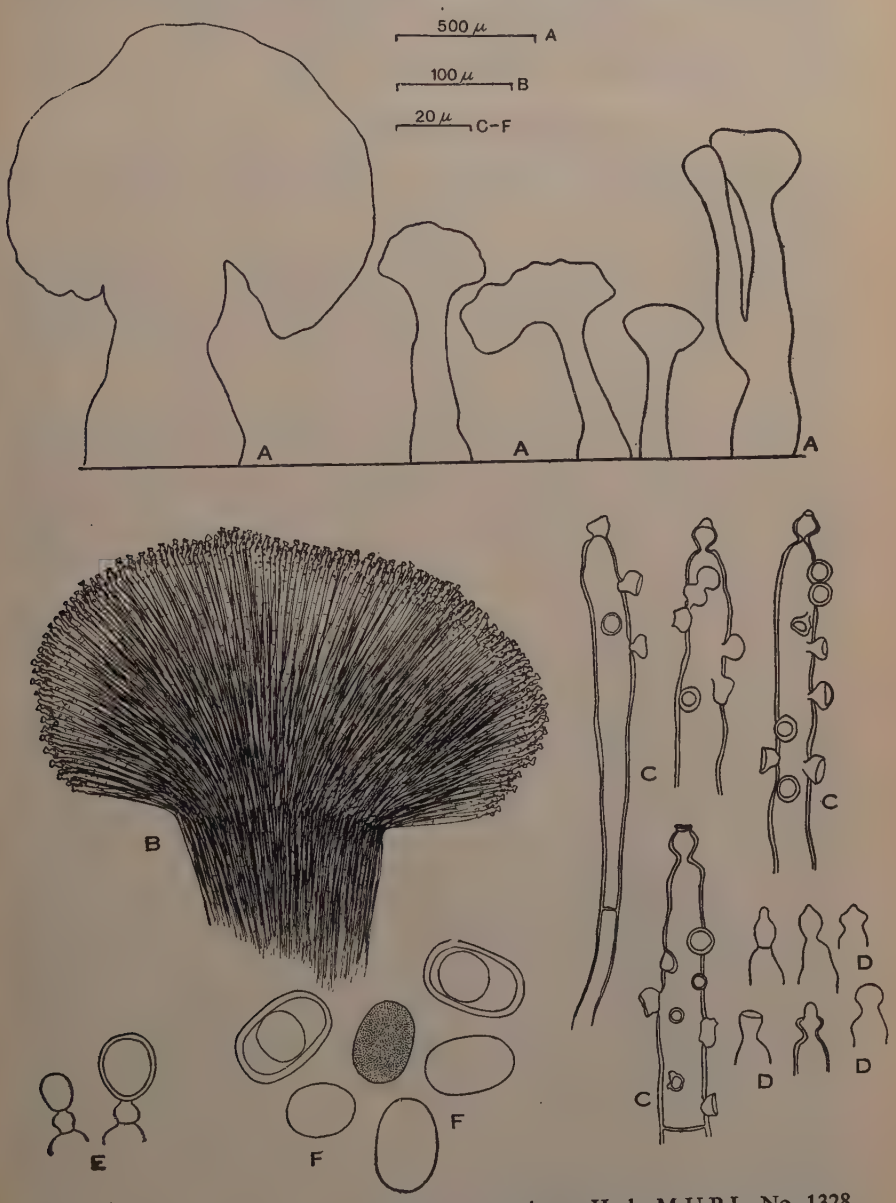

FIG. 9. *Paathramaya sundara* from type specimen, Herb. M.U.B.L. No. 1328. A, young and mature synnemata; B, fertile apex of a synnema; C, tips of conidiophores showing the cup-like protuberances at the tips of which conidia are produced; D, the apex of conidiophores; E, apex of conidiophores showing attachment of conidia; F, young and mature conidia.

a new genus to accommodate my fungus and I am naming it *Paathramaya sundara*, the generic and specific names being derived from Sanskrit: the generic name from पात्र (*paathra* = vessel, cup) and मय (*maya* = full of, with many), indicative of the many cup-like structures of the conidiophore; and the specific name from सुंदर (*sundara* = beautiful).

Paathramaya Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Hyphomycetas, Phæostilbæas, Amerosporas.

Synnemata erecta, simplicia, cylindrica, brunnea, conidiophoris capitatis, dense aggregatis in capitula hemisphærica vel globosa. Conidiophori simplices, sub-hyalini vel pallide brunnei, septati, ad apices fertiles, efformantes conidia singula ad apices tuberum acrogenorum atque pleurogenorum et cyathiformium. Conidia brunnea, unicellulata, haud catenata.

Fungus imperfectus, hyphomycete, Phæostilbeæ, Amerosporæ.

Synnemata erect, simple, cylindrical, brown, with capitate, hemispherical to globose head of closely aggregated conidiophores. Conidiophores simple, sub-hyaline to pale brown, septate, fertile towards the apex, producing conidia singly at the tips of acrogenous and pleurogenous cup-like protuberances. Conidia brown, one-celled, non-catenate.

Type species

Paathramaya sundara Subramanian sp. nov.

Synnemata dispersa in substratum, fusca vel nigro-brunnea, singula ornata pediculo atque capitulo capitato concolore. Stipes erectus, rectus vel curvatus, subcylindricus, 360–750 μ longus, 112–280 (–532) μ crassus ad basim, 35–140 (–322) μ crassus ad medium, 84–182 (–420) μ crassus sub ipso capite, constans plurimis hyphis dense aggregatis, non-ramosis, septatis, subhyalinis vel pallide brunneis. Capitula hemisphærica vel irregulariter subglobosa, 266–532 (–1260) μ in diam., 168–280 (–700) μ alta, constantia ex apicibus liberis dense aggregatis conidiophororum. Conidiophori simplices, subcylindrici, singuli subhyalini sed brunnei in massa, fertiles atque non-septati ad apicem, septati infra, crassis parietibus præditi, marginibus undulatis, longitudinis variabilis, 10·2–13·6 μ lati ad partem fertilem, usque ad 6·8 μ lati infra (parte fertili usque ad 210 μ longa), singuli ornati uno tubere acrogeno atque usque 20 tuberibus cyathiformibus pleurogenis. Tubera acrogena 6·8–8·5 × 4·1–6·8 μ, pleurogena vero 5·1–8·5 μ diam. Conidia producta singula ad apices tuberum acrogenorum et pleurogenorum cyathiformium, unicellulata, ovata, fusce brunnea, ut plurimum una guttula prominenti et parietibus levibus atque crassis ornata, haud catenulata, 20–29 × 17–21 μ.

Typus lectus in ligno quodam emortuo in loco Narsapur, in provincia Hyderabad Deccan die 22 mensis augusti, anni 1955, a C.V.S. et positus in herbario M.U.B.L. sub numero 1328.

10. **Prathoda saparva** gen. et sp. nov.

Another interesting Stilbaceous fungus was also collected by me from the Narsapur forest area in the Hyderabad State, occurring on dead stems in moist situations. A description of the fungus is given below:

The fungus forms numerous dark synnemata on the substratum, occurring singly and scattered, or in small groups. Under a hand lens each stalk of a synnema appears to bear a crown of radiating hyphæ or fungal elements which are somewhat paler in colour. The synnemata are simple, sometimes branched once or repeatedly, erect, straight or bent, 770–980 μ tall and each synnema terminates in one or more obconical clusters of loosely arranged radiating hyphæ (conidiophores) producing conidia. The stalks of the synnemata are somewhat sub-cylindrical, are composed of closely aggregated parallel hyphæ which are unbranched, septate and pale brown in colour, 70–210 μ thick at the base and 56–84 μ thick in the middle. The closely aggregated parallel hyphæ of the stalk spread out towards the tip into one or more groups of loosely compacted clusters of conidiophores and this apical obconical crown of free conidiophore ends is paler in colour than the stalk and is 280–350 μ across and 224–378 μ tall. The conidiophores are simple, very rarely branched, of variable length, pale brown above, dark brown below, thick-walled, smooth, many-septate, constricted at the septa, geniculate, with cylindrical or barrel-shaped cells which are up to 17 μ long; cylindrical cells are 3·4–9·4 μ broad; barrel-shaped cells are 5·1–9·4 μ broad; and the conidiophore tips are 5·1–6·8 μ broad. The conidia are produced acrogenously and singly at the tips of the conidiophores. Successive formation of conidia from the same conidiophore takes place in two ways: (i) a new conidium initial may be formed immediately below the scar of the first formed conidium and when this is repeated a typical geniculate conidiophore results; (ii) the conidiophore may proliferate through the scar of the first formed conidium, grow for a short length and produce another conidium acrogenously and when this process is repeated a conidiophore with many intercalary swellings results. Both types of conidial formation may be found in one and the same conidiophore. The conidia are typical scolecospores of the *Cercospora* type, hyaline to sub-hyaline, long, whip-like, many- (up to 15-) septate, broadest immediately above the basal cell and becoming narrower and almost filiform above, and constricted at the septa in the lower part of each conidium. The conidia are 182–294 μ long. The lowermost cell of the conidium is 6·8 μ broad. The conidium is 8·5–10·2 μ thick where it is broadest and 2·5–3·4 μ broad above where it is filamentous and of uniform thickness.

The fungus clearly belongs to the Stilbaceæ, and its most noteworthy feature is the possession of many-celled conidia which are typical scolecospores. The only genus of the Stilbaceæ known to possess scolecospores is *Pterulopsis* Wakefield and Hansford (*apud* Hansford, 1943, p. 64), but the type species of this genus (*P. dummeri*) produces whitish synnemata and has one-celled hyaline scolecospores

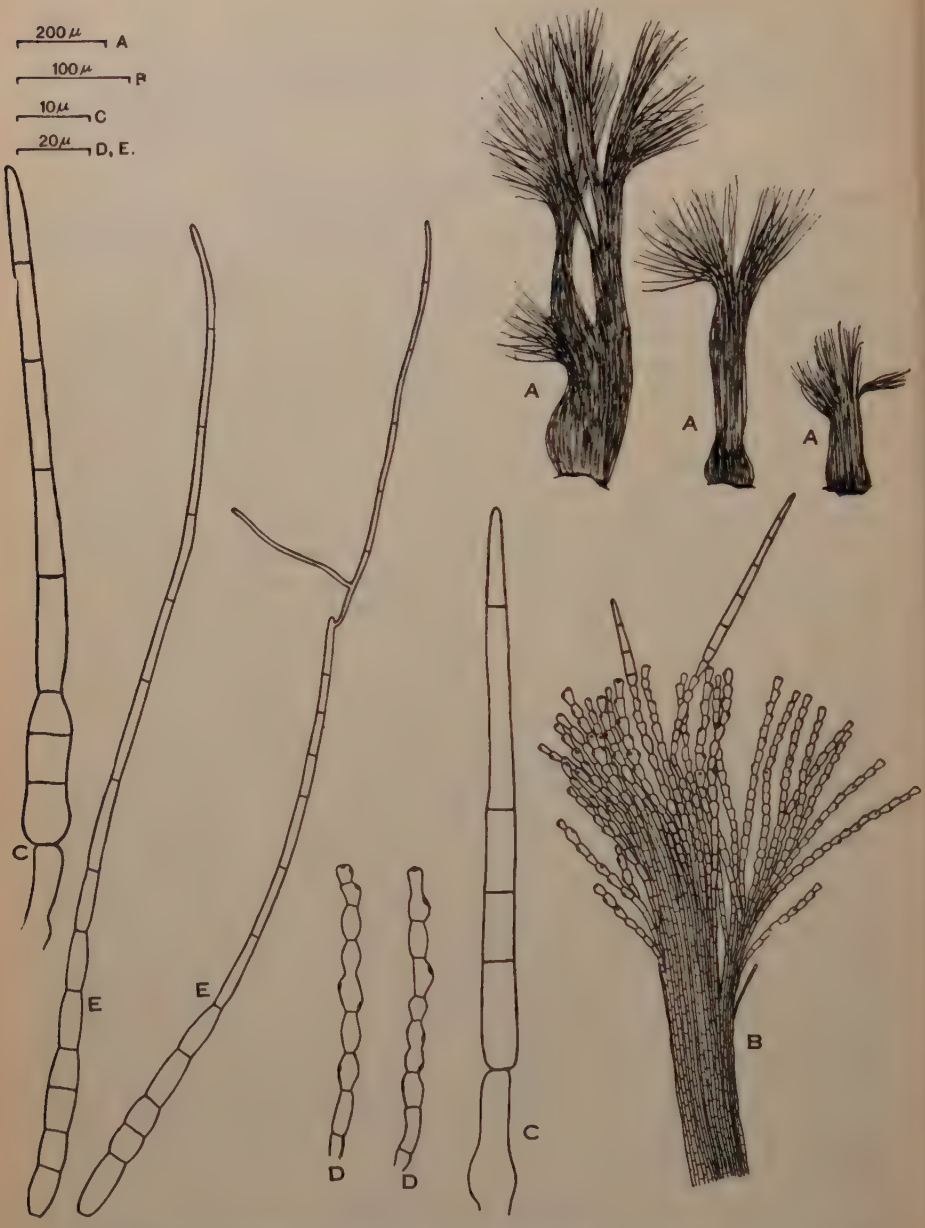

FIG. 10. *Prathoda saparva* from type specimen, Herb. M.U.B.L. No. 1325. A, young and mature synnemata; B, fertile apical part of a synnema; C, conidiophore tips showing attachment of young conidia; D, apical portions of conidiophores showing geniculations; E, two mature conidia, of which one has germinated.

and is placed in the Hyalo-Scolecosporæ. My fungus is obviously not a *Pterulopsis*, since the former belongs to the Phæostilbeæ and has many-septate scolecospores. I am, therefore, proposing a new genus for it and am naming it *Prathoda saparva*, the generic and specific names being derived from Sanskrit: the generic name from प्रतोद (*prathōda* = a long whip), from the resemblance of the scolecospores to a long whip; and the specific epithet from सपर्व (*saparva* = divided), suggestive of the septate nature of the conidia.

Prathoda Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Hyphomycetas, Phæostilbeas, Scolecosporas.

Synnemata erecta, fusce brunnea, simplicia vel ramosa, una alterave aggregatione conidiophororum apicali ornata. Conidiophori simplices vel ramosi, brunnei, septati, geniculati. Conidia hyalina vel subhyalina, longa, scolecospora, pluriseptata, producta singula atque acrogene ex apice conidiophororum; productio successiva conidiorum per incrementum conidiophororum per cicatricem conidii prævii, vel per incrementum renovatum prævii conidii immediate infra cicatricem.

Fungus imperfectus, hyphomycete, Phæostilbeæ, Scolecosporæ.

Synnemata erect, dark brown, simple or branched with one or more apical clusters of conidiophores. Conidiophores simple or branched, brown, septate, geniculate. Conidia hyaline to sub-hyaline, long, scolecosporous, many-septate, produced singly and acrogenously from the tips of conidiophores. Successive production of conidia by growth of conidiophore through scar of previous conidium or by renewed growth from just below scar of previous conidium.

Type species

Prathoda saparva Subramanian sp. nov.

Synnemata plura, singula vel aggregata super substratum, fusca, simplicia, aliquando semel vel pluries furcata, erecta, recta vel curvata, desinentia in unam pluresve catervas obconicas fasciculorum laxe aggregatorum hypharum (conidiophororum) quæ conidiis ortum dant, 770–980 μ alta. Stipites subcylindrici, constantes e hyphis dense aggregatis, parallelis, non-ramosis, septatis, pallide brunneis, 70–210 μ crassi ad basim, 56–84 μ crassi in medio. Fasciculis apicalis radians conidiophororum 280–350 μ diam., 224–378 μ altus. Conidiophori simplices, raro ramosi, longitudinis variabilis, fusce brunnei infra, pallide brunnei supra, crassis parietibus præditi, leves, pluriseptati, constricti ad septa, geniculati, cylindricis vel doliiformibus cellulis ornati usque ad 17 μ longi. Cellulæ cylindricæ 3·4–9·4 μ latæ; doliiformes vero usque 5·1–9·4 μ latæ; conidiophororum apices 5·1–6·8 μ crassi. Conidia hyalina vel subhyalina, longa, scolecospora, usque ad quindecies septata, latissima immediate supra infimam cellulam atque gradatim angustiora evadentia sursum, fastigata in caudam filiformen crassitudinis uniformis, 182–294 μ longa, acrogene producta atque singula ex apicibus conidiophororum; infima cellula conidii 6·8 μ lata. Conidium 8·5–10·2 μ

latum in parte latissima, 2·5–3·4 μ in parte filiformi crassitudinis uniformis. Productio successiva conidiorum per incrementum conidiophororum per cicatricem conidii prævii vel per incrementum renovatum prævii conidii immediate infra cicatricem.

Typus lectus in culmo quodem emortuo in loco Narsapur, in provincia Hyderabad-Deccan, die 22 mensis augusti, anni 1955, a C.V.S. et positus in herbario M.U.B.L. sub numero 1325.

11. *Spegazzinia tessarthra* (Berk. & Curt.) Sacc., 1886, *Sylloge Fungorum*, **4**: 758; Damon, S. C., 1953, *Bull. Torrey bot. Cl.*, **80**: 162; Hughes, S. J., 1953, *Mycol. Pap.*, **50**: 62–64.

=*Sporidesmium tessarthrum* Berk. & Curt., 1869, *J. Linn. Soc.* (*Bot.*), **10**: 355.

=*Spegazzinia ornata* Sacc., 1880, *Rev. mycol. Toulouse*, **2**: 140; 1886, *Sylloge Fungorum*, **4**: 758.

=*Tetrachia quadrigemina* Berk. & Curt. ex Cooke, 1884, *Grevillea*, **12**: 97.

=*Triposporium cristatum* Pat., 1888, *Bull. Soc. mycol. Fr.*, **4**: 125; Saccardo, 1892, *Sylloge Fungorum*, **10**: 739.

=*Spegazzinia tucumanensis* Speg., 1896, *Rev. Fac. Agron. La Plata*, **19**: 256; Saccardo, 1899, *Sylloge Fungorum*, **14**: 1132.

=*Spegazzinia brasiliensis* Speg., 1919, *Bol. Acad. nac. Ciencas*, **23**: 538; Saccardo, 1931, *Sylloge Fungorum*, **25**: 997.

The fungus forms black pulverulent colonies of variable shape and size on the substratum. Two types of conidia are produced: the spiny and the smooth.

The spiny conidia are dark brown in colour and composed of four cells adpressed in one plane. They are 17–26 μ broad, 15–26 μ tall and 13–16 μ thick, excluding the spines. Each conidium bears a number of pale brown to sub-hyaline, irregular, straight or curved spines up to 12 μ long and 1–2 μ thick at the base. The conidiophore is inserted towards the inner angle of one of the four cells of the conidium in such a way that the plane of the four cells of the conidium is at right angles to the conidiophore. The conidiophores bearing these spiny conidia may be long macroconidiophores or short microconidiophores. The macroconidiophores are brown, simple, thick-walled, non-septate, erect, straight, bent or flexuous, 80–150 μ long, up to 4·2 μ thick at the tip and 1–2 μ thick elsewhere. The microconidiophores are similar to the macroconidiophores but much shorter, being 25–60 μ long. The conidiophores arise from a conspicuous swollen conidiophore mother cell 5·1–7·7 μ tall and 4·2–5·1 μ thick. This swollen cell is produced laterally from cells of the repent hyphæ which are 1–3 μ thick, sub-hyaline, septate and branched.

The smooth conidia are dark brown, disc-shaped and flattened in a vertical plane, cruciately divided by oblique septa into four equal somewhat triangular cells, constricted at the septa, attached to the conidiophore by the broad side of one of the four cells, 12–17 μ long and wide and 8–9 μ thick. Invariably, each conidium has a short, thin pedicel indicating the point of attachment to the conidiophore; the pedicel is up to 5 μ broad, up to 2 μ tall, and is sub-hyaline. The conidia are produced on extremely short conidiophores about 3 μ long and 5 μ thick.

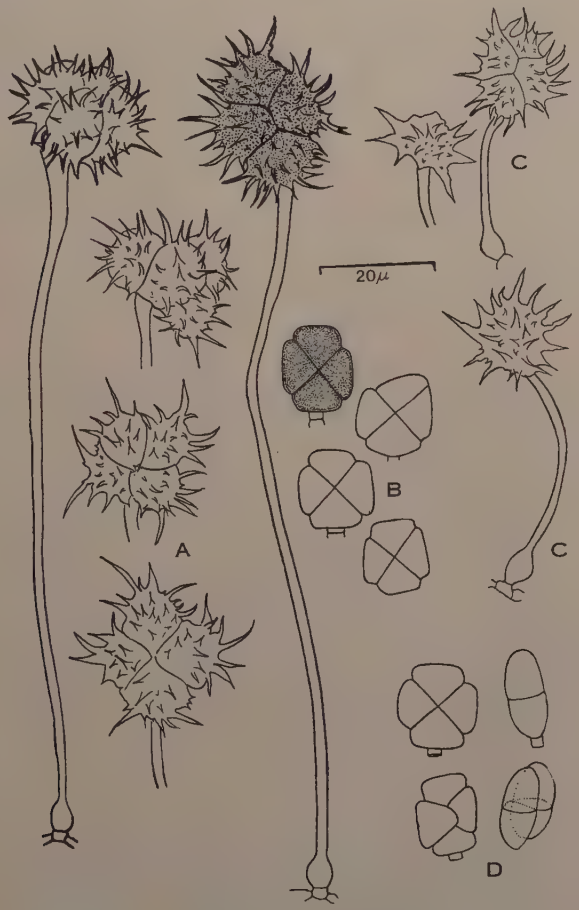

FIG. 11. *Spegazzinia tessarthra*. A, B, spiny and smooth conidia from Herb. M.U.B.L. No. 1383; C, D, the same from Herb. M.U.B.L. No. 1387.

Two collections of this fungus have been seen: on dead culms of grass, Sim's Park, Coonoor (Nilgiris District, Madras State), coll. C.V.S., 23–9–1955 (Herb. M.U.B.L. No. 1387); 25–9–1955 (Herb. M.U.B.L. No. 1384).

An earlier report of this fungus from India is that of Chona and Munjal (1950) who collected it on dead leaves of *Cynodon dactylon* at New Delhi and recorded it as *S. ornata* Sacc.

12. **Spegazzinia sundara** sp. nov.

The fungus forms black, pulverulent colonies of variable size on the substratum. The sporodochia are of variable size, and consist of closely aggregated clusters of numerous conidiophores and conidia. Two types of conidia are produced: the spiny and the smooth.

Spiny conidia and conidiophores.—The spiny conidia are of variable shape and size, dark brown in colour, and may be 1–4-celled. They are borne singly and acrogenously at the tips of conidiophores. Each conidium is ornamented all over with many spines which are up to $8 \cdot 5 \mu$ long and $2 \cdot 5 \mu$ wide. The one-celled conidia are sub-globose to ovoid and measure 10–12 μ in diameter, excluding the spines; the two-celled ones measure $20 \times 12 \mu$ and the four-celled ones $25 \cdot 5$–$30 \cdot 6 \times 15 \cdot 3$–$23 \cdot 8 \mu$. The conidial septa are oriented as in the case of *Spegazzinia tessarthra*, but there is greater cleavage so that the conidia appear deeply lobed. The conidiophores are simple, long and filamentous, erect, straight or flexuous, pale brown, non-septate, (21)–79–137 μ long, 2–3 μ broad at the apex, and 1–2 μ broad below.

Smooth conidia and conidiophores.—The smooth conidia are dark brown in colour, disc-like and flattened in a vertical plane, cruciately divided into four somewhat equal cells, deeply constricted at the septa, having irregularly lobed edges, $18 \cdot 7$–$25 \cdot 5 \mu$ long and wide and 9–10 μ thick. In most cases the basal cell of the conidium is somewhat conical, the apical cell is obconical and the two middle cells which are found in the same plane are separated by a narrow vertical septum; the apical and the basal cells are separated by the two middle cells. Rarely, the conidia may have fewer cells or sometimes up to 7 cells, but these may be considered abnormalities. The conidia are produced acrogenously and singly at the tips of conidiophores and are attached to the conidiophores by the broad ends of their basal cells. The conidiophores are simple, of uniform thickness throughout or possessing one or more constrictions, non-septate, sub-hyaline to pale brown, erect, straight or flexuous, thin and filamentous, (16)–21–69 μ long, $3 \cdot 4$–$5 \cdot 1 \mu$ broad at the apex, and 1–3 μ thick at the base.

Two collections in the Herb. M.U.B.L. are being assigned to this taxon, *viz.*, No. 1362 and No. 585. The description given above is based on a study of No. 1362. No. 585 has both types of conidia: the spiny ones are 2–4-celled, $13 \cdot 6$–$20 \cdot 4 \mu$ long, $11 \cdot 9$–$17 \cdot 0 \mu$ across (excluding the spines), the spines being up to $4 \cdot 2 \mu$ long and $1 \cdot 7 \mu$ thick; they are borne on conidiophores which are 61–162 μ long. The smooth conidia measure $13 \cdot 6$–$17 \cdot 0 \times 11 \cdot 9$–$15 \cdot 3 \mu$ and are about 10 μ thick; they are similar to those of No. 1362, are slightly smaller and the lobing of the four cells is less conspicuous, but nevertheless is present. Further, these conidia appear to be produced on very short, inconspicuous conidiophores.

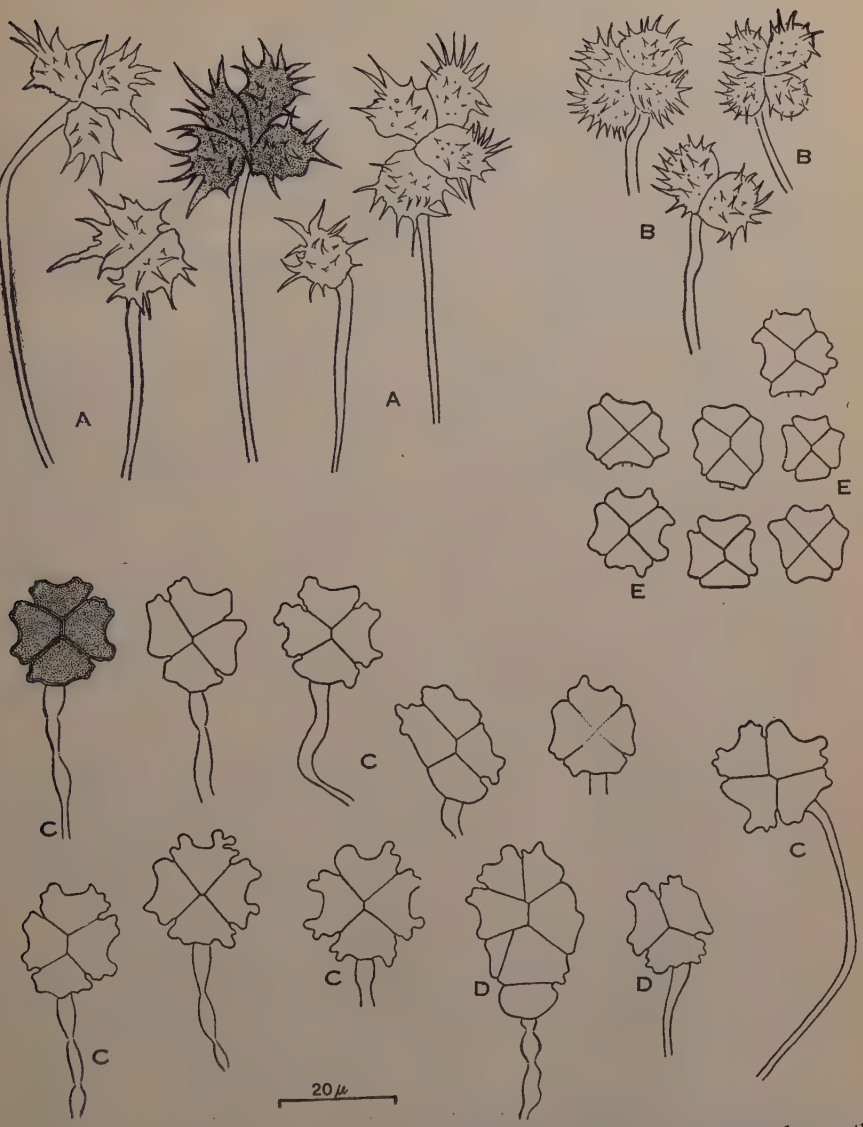

FIG. 12. *Spegazzinia sundara.* A, B, spiny conidia; C, E, normal smooth conidia; D, abnormal smooth conidia. A, C, D, from type specimen, Herb. M.U.B.L. No. 1362; B, E, from Herb. M.U.B.L. No. 585.

It will be obvious from the above description that my fungus is quite distinct from *Spegazzinia tessarthra* in having highly lobed smooth conidia and their larger size compared to the smooth conidia of *S. tessarthra.* On the basis of these differences, I propose to describe my fungus as a new species of *Spegazzinia.*

Spegazzinia sundara Subramanian sp. nov.

Sporodochia nigra, pulverulenta, magnitudinis variabilis. Conidia duplicis formæ: spinosa et levia.

Conidia spinosa magnitudinis et formæ variabilis, fusce brunnea, 1–4-cellulata, producta singula acrogene ad apices conidiophororum; spinulæ usque ad 8·5 μ longæ, 2·5 μ crassæ; conidia unicellulata subglobosa vel ovoidea, 10–12 μ diam. (spinulis exclusis); conidia bicellulata 20 × 12 μ; conidia 4-cellulata vero 25·5–30·6 × 15·3–23·8 μ. Conidiophori supportantes conidia spinosa simplices, longi, filiformes, erecti, recti vel incurvi, non-septati, pallide brunnei, (21)–79–137 μ longi, 2–3 μ lati ad apicem, 1–2 μ lati infra.

Conidia levia brunnea, discoidea et complanata in plano verticali, cruciformiter divisa in 4 cellulas plus minusve aequales (cellula basal conica, cellula apicali obconica, duplici cellula media separata per septum breve verticale), alte constricta ad septum, marginibus irregulariter lobatis, 18·7–25·5 μ longa et lata, 9–10 μ crassa, infixa conidiophoro per marginem latum cellulæ basalis. Conidiophori supportantes conidia simplices, filiformes, crassitudinis uniformis, vel semel bisve constricti, non-septati, subhyalini vel pallide brunnei, erecti, recti vel flexuosi, (16)–21–69 μ longi, 3·4–5·1 μ lati ad apicem, 1–3 μ crassi ad basim.

Typus lectus in quadam planta bambusina emortua, in campo "Corporation Zoo", in urbe Madras, die 9 mensis septembris anni 1955 a C.V.S. et positus in herbario M.U.B.L. sub numero 1362; lectus etiam in foliis emortuis *Ananas sativæ* Schult. f., in Chingavanam, T.C. State, die 8 mensis octobris 1951, a K. Ramakrishnan et positus in herbario M.U.B.L. sub numero 585.

Recently, Hughes (1953, p. 65) described a new variety of *Spegazzinia tessarthra*, *viz.*, v. *deightonii* from the Gold Coast and it was characterised as follows: "A typo ita differt: conidia 8-cellulata." This new variety *deightonii* is sufficiently distinct from *S. tessarthra* as to merit specific rank. Accordingly, I propose to accord specific rank to this variety:

Spegazzinia deightonii (Hughes) Subramanian comb. nov.

Basonym.—*Spegazzinia tessarthra* (Berk. & Curt.) Sacc. var. *deightonii* Hughes, 1953, *Mycol. Pap.*, **50**: 65.

Type.—On *Saccharum officinarum*, Gold Coast (Colony), Takoradi, 10–5–1949, Herb. I.M.I. 38568 (*b*).

13. **Sporidesmium nilgirense** sp. nov.

This interesting fungus was collected on dead bamboo (*Bambusa nana* Hort.) from the Government Gardens, Ootacamund (Nilgiris), during a visit in 1953. The colonies on the substratum are dark brown and effuse. The repent hyphæ are sub-hyaline to pale brown, branched, septate and 2–4 μ broad. The conidiophores arise laterally from cells of the repent hyphæ or on short one-celled lateral branches therefrom. They are simple, short, somewhat cylindrical, erect, straight or bent, brown, 3–5-septate, up to 90 μ long and 5·9–8·5 μ broad. The conidia are produced acrogenously and singly at the tips of the conidiophores. They are elongate-obclavate, broadest immediately above the base,

becoming progressively narrower and finally tapering to somewhat uniform thickness above, many times transversely septate and constricted at the septa. Each conidium has a flat base 4·2–5·1 μ broad where it is attached to the conidiophore. The conidia are 70–210 μ long, 11·9–15·3 μ where they are broadest and 4·2–6·8 μ broad at the tips. They are dark brown, may be slightly paler in colour towards the apex and are straight, bent or curved.

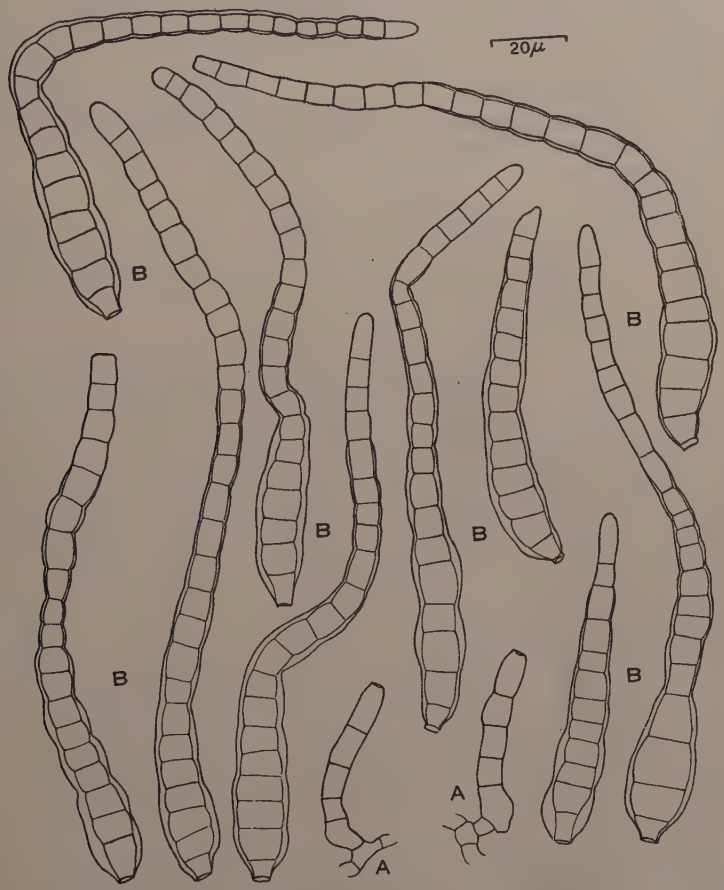

FIG. 13. *Sporidesmium nilgirense* from type specimen, Herb. M.U.B.L. No. 1031. A, conidiophores; B, mature conidia.

I consider that the fungus just described is best placed in the genus *Sporidesmium* and since it appears to differ from species of this genus so far known, I am describing it as a new species.

Sporidesmium nilgirense Subramanian sp. nov.

Coloniæ fusce brunneæ, effusæ. Hyphæ repentes subhyalinæ vel pallide brunneæ, ramosæ, septatæ, 2–4 μ latæ. Conidiophori surgentes

lateraliter e cellulis hypharum repentium vel e ramulis brevibus unicellulatis lateralibus hypharum repentium, simplices, breves, aliquantum cylindrici, erecti, recti vel curvati, brunnei, 3–5-septati, usque ad 90 μ longi, 5·9–8·5 μ lati. Conidia elongato-obclavata, latissima supra ipsam basim, progressive evadentia angustiora atque tandem desinentia supra in partem uniformiter crassam, fusce brunnea colore, tenuiter pallidiora ad apicem, recta, curvata vel flexa, sæpissime transverse septata, constricta ad septa, 70–210 μ longa, 11·9–15·3 μ ad partem latissimam, 4·2–6·8 μ lata ad apicem, singula conidia ornata basi plana 4·2–5·1 μ lata.

Typus lectus in culmis emortuis *Bambusæ nanæ* Hort. in "Government Gardens", in loco Ootacamund, in dist. Nilgiris, provincia Madras, die 9 mensis decembris anni 1953, a T. S. Sadasivan et positus in herbario M.U.B.L. sub numero 1031.

14. *Stigmina maculata* (Cooke) Hughes, 1952, *Mycol. Pap.*, **49**: 11.

≡*Clasterosporium maculatum* Cooke, 1876, *Grevillea*, **4**, No. 31, 117; Saccardo, 1886, *Sylloge Fungorum*, **4**: 392.

?=*Exosporium fici* Payak & Thirum. (*nomen nudum*) *apud* Payak, 1953, *Sci. & Cult.*, **18**: 343.

A collection of this fungus was made from the Mysore State during a visit in 1953. The fungus forms dark brown, irregular colonies on living leaves and the colonies consist of clusters of conidiophores arising from immersed stromata. The conidiophores are somewhat cylindrical, simple, erect, straight or bent, often somewhat broader towards the base, dark brown below, paler above, with hyaline tip, up to 3-septate, 28–55 μ long and 5·1–6·0 μ wide. The basal cell of the conidiophore may be up to 12 μ broad. The conidia are produced acrogenously and singly at the tips of conidiophores. They are mostly sub-cylindrical to obclavate, with a broad and flat base, broadest towards the middle or nearer the base, gradually or somewhat suddenly tapering above into a narrow elongate apex, dark brown in colour but becoming paler towards the tip which is sub-hyaline, smooth, up to 7-septate, not constricted at the septa, 30–75 μ long, and 5·1–8·5 μ thick where they are broadest. The conidia are 3·4–6·0 μ thick at the base.

Habit.—On living leaves of *Ficus* sp., Chamundi Hills, Mysore, coll. K.R. & C.V.S., 11–10–1953, Herb. M.U.B.L. No. 919.

The fungus appears to be identical with the type collection of *Clasterosporium maculatum* Cooke, "on leaves of *Ficus cordifolia*, India, coll. Hobson [616]", as re-described and figured by Hughes (1952, pp. 11–13), notwithstanding the fact that the conidia in the type collection were stated to be mostly 8–9 (mostly 9)-septate, whereas in my fungus they are not more than 7-septate. I have followed Hughes in classifying the fungus under *Stigmina*.

Payak (1953) recently reported *Exosporium fici* Payak & Thirum. n.sp. on living leaves of *Ficus bengalensis* from Poona, Bombay State.

No description was given. I have not seen a specimen either; but it is not unlikely that Payak's fungus is the same as *Stigmina maculata*.

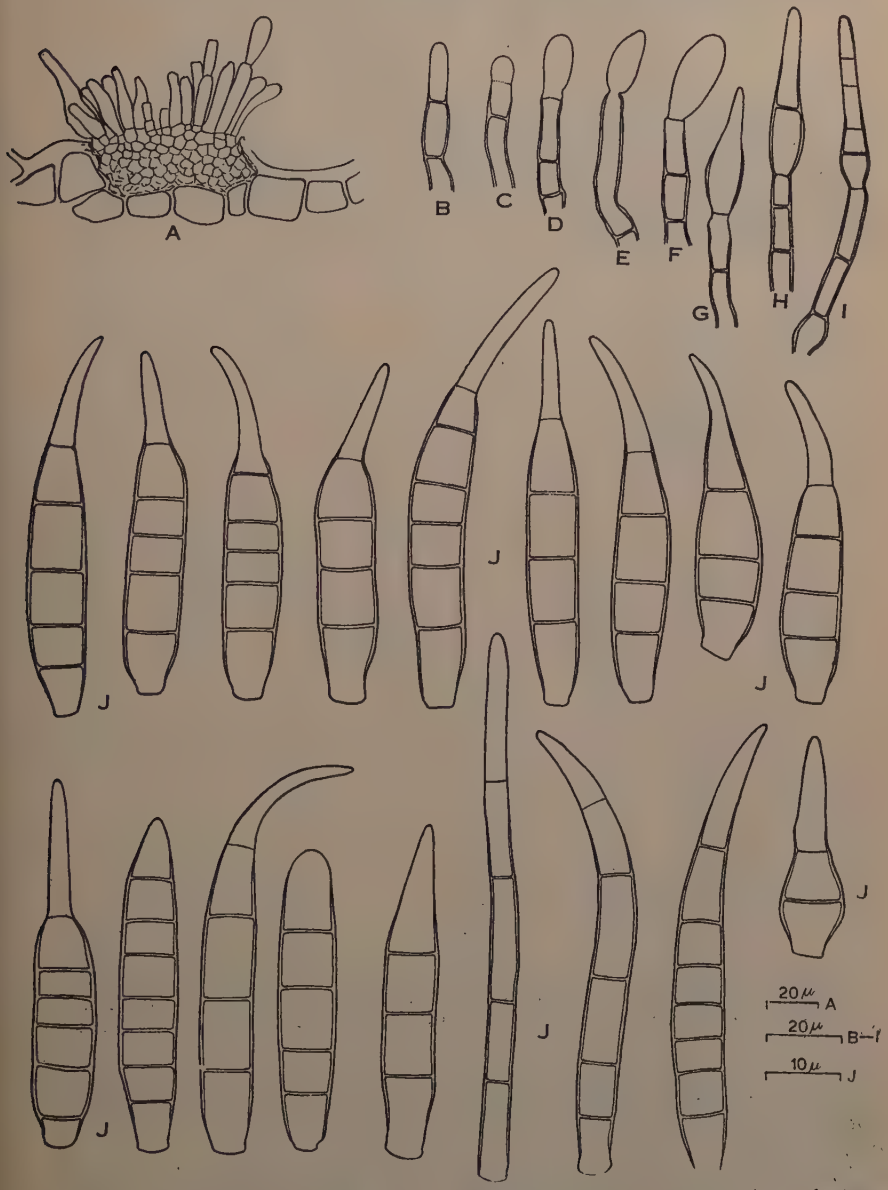

FIG. 14. *Stigmina maculata* from Herb. M.U.B.L. No. 919. A, a cluster of conidiophores; B–I, development of conidia; J, mature conidia.

It is noteworthy that the type collection of *Clasterosporium maculatum* is from Kolapore, Bombay State (Butler and Bisby, 1931).

15. *Stigmina palmivora* (Sacc. *apud* Trelease) Hughes, 1952, *Mycol. Pap.*, **49**: 13.

≡*Exosporium palmivorum* Sacc. *apud* Trelease, 1898, *Rep. Mo. bot. Gdns.*, **9**: 159; Saccardo, 1902, *Sylloge Fungorum*, **16**: 1106; Butler, E. J. & Bisby, G. R., 1931, *Sci. Monogr. Coun. agric. Res. India*, **1**: 145.

A collection of this fungus, occurring on living leaves of *Phœnix* sp., was recently made from the Nilgiris. The fungus causes leaf spots which are angular or rounded, pale brown to brownish-black and of variable size. Each spot has clusters of conidiophores bearing conidia. The conidiophores arise from a stromatic base which is immersed in

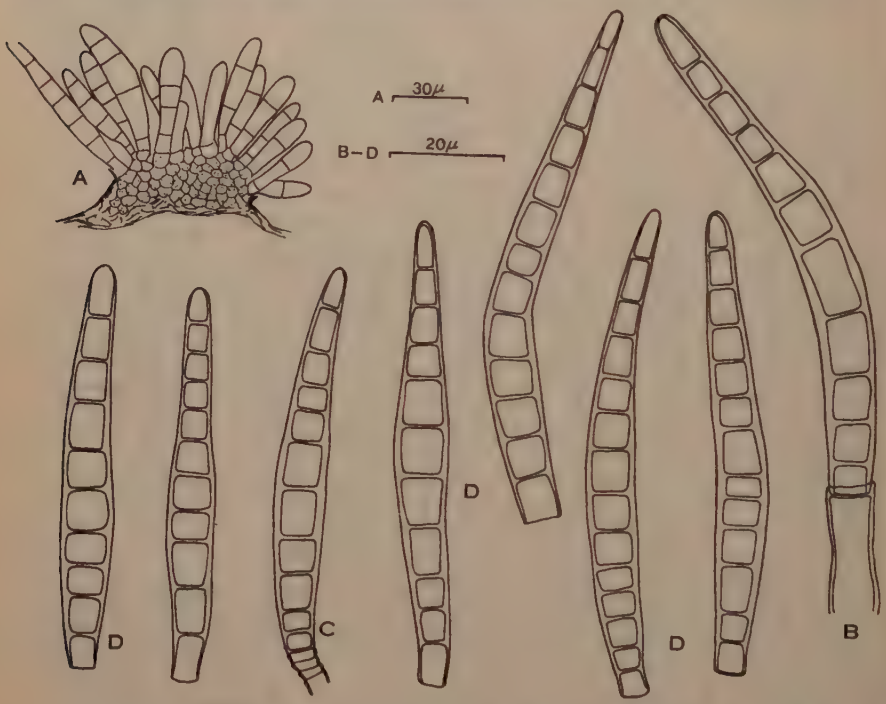

FIG. 15. *Stigmina palmivora*, from Herb. M.U.B.L. No. 991. A, a cluster of conidiophores; B, C, showing attachment of conidia to conidiophores; D, mature conidia.

the host tissue. They are short, simple, cylindrical, brown, up to 15 μ long and 5·1–6·8 μ broad at the tip, and straight or slightly bent. The conidia are produced acrogenously and singly at the tips of the conidiophores. They are fusoid-clavate, with a rounded apex and a lower portion tapering gradually to a flat scar, straight, bent or curved, pale to dark brown, thick-walled, verrucose, up to 13-septate, 72–108 μ long, 5·1–6·8 μ broad at the base, 8·5–10·2 μ where they are broadest, and 4·3–6·8 μ broad at the tip.

Only one collection has been made: on living leaves of *Phœnix* sp., Sim's Park, Coonoor (Nilgiris District, Madras State), 8–12–1953, coll. T. S. Sadasivan and C. V. S., Herb. M.U.B.L. No. 991.

16. **Tharoopama trina** gen. et sp. nov.

The fungus forms conspicuous scattered, superficial, erect synnemata on the substratum, *viz.*, dead culms of grass occurring in moist leaf litter. Under a hand lens, each synnema is seen to have a short, simple, brownish-black stalk and an apical head which is ash gray in colour and may be globose, oval or somewhat irregular in outline. The synnemata are 740–1470 μ tall and the apical heads up to 1190 μ in diameter. The structure of the fungus as revealed by microscopic examination is as follows: The synnema has a dark brown stalk which is somewhat cylindrical, simple, swollen at the base, and composed of numerous pale olivaceous brown, unbranched, septate, parallel hyphæ up to 4 μ thick closely aggregated together. The stalks are 504–1050 μ long, 84–140 μ thick at the base and 42–70 μ thick above. Usually, well over half the upper portion of each stalk is fertile and in this region the individual hyphæ of the synnema progressively become free and diverge from the main stalk to form the conidiophores. The fertile portion of the stalk is usually 350–910 μ long and the diameter of the fertile part including the much branched conidiophores is 460–1190 μ. The conidiophores, which are the free ends of the hyphæ of the synnema, are brown in colour, but progressively become paler and finally hyaline towards the tips. They are 84–350 μ long, diverging at varying angles with reference to the main stalk of the synnema, straight, bent or curved, septate (the distance between septa varying from 14–29 μ), 3–8 μ thick, and branched. Conidiophore branches are produced laterally from cells of the main conidiophore, mostly immediately below septa and confined to one side of the conidiophore. These branches may be formed at right angles to the main conidiophore or else may form an acute angle with the latter. Secondary and tertiary branches may be porduced in the same way. In cases where more than one lateral branch arise from the sub-apical cell of the main conidiophore or a branch, or from any other cell of the conidiophore or its branches, a resemblance to a verticil is seen, but they are not true verticils. Indeed, the branching described above reminds one of the conidiophores of *Hansfordia* spp. recently described by Hughes (1951 *b*). The ultimate branches, which alone bear conidia, are hyaline, subcylindrical, one-celled, 14–33 μ long and 3–4 μ wide. The conidia are produced acrogenously and singly from the tips of the ultimate one-celled branches and successive production of conidia from the same conidiophore by renewed growth immediately below the scar of the fallen conidium gives the tips of ultimate branches a geniculate appearance. The geniculations may not be seen in young synnemata in which conidial production has just started, but are conspicuous in older ones. The conidia are globose with a basal apiculus, hyaline, smooth, one-celled, and 3–4 μ in diameter.

The fungus just described is easily placed in the Moniliales-Phæostilbeæ, but I know of no genus in which it can be accommodated,

The nature of the conidiophore, its branching, the geniculate character of the ultimate branches and the one-celled conidia are suggestive of *Hansfordia* spp. (Hughes, 1951 *b*). My fungus, however, is not a

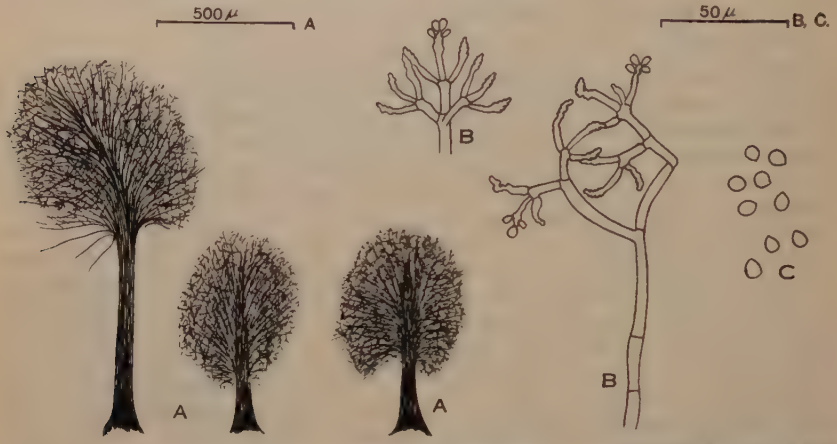

FIG. 16. *Tharoopama trina* from type specimen, Herb. M.U.B.L. No. 1416. A, synnemata; B, portions of conidiophores showing their branching and the production of conidia; C, mature conidia.

simple Dematiaceous one but forms distinct and conspicuous synnemata. I am, therefore, proposing a new genus for its accommodation and naming it *Tharoopama trina*. The generic and specific names are derived from Sanskrit: the generic name from तरु (*tharu* = tree) and उपम (*upama* = like, resembling), suggestive of the tree-like appearance of the synnemata; the specific name from त्रिण (*trina* = grass), from the substratum (grass) on which it was collected.

Tharoopama Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Stilbaceas, Phæostilbeas, Amerosporas.

Synnemata superficialia, erecta, stipite atque capitulo bene definitis. Stipes erectus, subcylindricus, fertiles supra, constans e hyphis dense aggregatis, parallelis, haud ramosis, septatis, brunneis. Singulæ hyphæ synnematum progressive liberæ evadunt in parte fertili stipitis atque ex stipite divergunt ad efformandos conidiophoros. Conidiophori subhyalini vel brunnei, septati, semel furcati vel bis terve. Ramuli tantum finales fertiles, semel cellulati, geniculati ad apicem. Conidia acrogene producta singulariter ad apices ramulorum terminalium vel ex successivis punctis crescentibus novis, quæ immediate sub cicatrice conidii lapsi surgunt, hyalina, globosa, semel cellulata.

Fungus imperfectus, Moniliales, Stilbaceæ, Phæostilbeæ, Amerosporae.

Synnemata superficial, erect, with well-defined stalk and head. Stalk erect, subcylindrical, fertile above, composed of closely aggre-

gated parallel, unbranched, septate, brown hyphæ. Individual hyphæ of synnema progressively becoming free in the fertile part of stalk, diverging from the stalk to form conidiophores. Conidiophores subhyaline to brown, septate, branched once, twice or thrice. Ultimate branches alone fertile, one-celled, geniculate towards the apex. Conidia produced acrogenously and singly at the tips of ultimate branches or from successive new growing points arising from immediately below the scar of a fallen conidium, hyaline, globose, one-celled.

Type species

Tharoopama trina Subramanian sp. nov.

Synnemata dispersa in substratum, conspicua, superficialia, erecta, 740–1470 μ alta, stipite atque capitulo bene definitis, capituli diametro 460–1190 μ. Stipes nonnihil cylindricus, simplex, ad basim tumescens, constans e plurimis hyphis (quæ sunt olivaceo-brunneæ, non-ramosæ septatæ, usque ad 4 μ crassæ, dense aggregatæ), 504–1050 μ longus, 84–140 μ crassus ad basim, 42–70 μ crassus supra. Ut plurimum dimidium superius stipitis vel plus quam dimidium fertile, hyphis singulis synnematis in hac parte progressive liberis evadentibus atque divergentibus ex stipite principali ad efformandos conidiophoros. Pars fertilis stipitis 350–910 μ longa. Conidiophori brunnei, progressive evadentes pallidiores atque tandem hyalini ad apices, 84–350 μ longi, divergentes ex stipite synnematis ad angulos varios, recti, curvati vel flexi, septati, 3–8 μ crassi, ramosi. Conidiophororum ramuli primarii, secundarii et tertiarii, producti lateraliter ex cellulis conidiophori ut plurimum immediate sub septis, atque ut plurimum ad unum latus conidiophori vel ramulorum restricti. Ramuli terminales hyalini, subcylindrici, semel cellulati, 14–33 μ longi, 3–4 μ lati, geniculati ad apices. Conidia producta acrogene atque singulariter ex apicibus ramulorum terminalium vel ex successivis punctis crescentibus immediate sub cicatrice conidii lapsi, globosa, apiculata, hyalina, semel cellulata, lævia, 3–4 μ diam.

Typus lectus in culmis emortuis cuiusdam graminis (an *Cynodontis dactyli* ?) in stramento foliorum humido, in campo Laboratorii Botanici Universitatis, Madras, die 9 mensis novembris anni 1955, a C. V. S. et positus in herbario M.U.B.L. sub numero 1416; lectus etiam in leguminibus emortuis *Cæsalpiniæ pulcherrimæ* Sw. in stramento foliorum humido eodem loco die 10 mensis novembris anni 1955 ab eodem auctore et positus in herbario M.U.B.L. sub numero 1419.

From a study of literature, I find that a fungus closely resembling *Tharoopama trina* has been previously described by Penzig and Saccardo (1904), *viz.*, *Trichosporium arborescens* (Saccardo, 1906, p. 573). *T. arborescens* is not a *Trichosporium*. It cannot even be a *Hansfordia*, as suspected by Hughes (1951 *b*, p. 24). Penzig and Saccardo described their fungus as follows: "Cæspitosum, latum, brunneogriseum; hyphis filiformibus prælongis, 5 μ cr., liberis v. fasciculato-connexis, atro-fuligineis, sursum iterato et crebro ramosis, paniculam amplam formantibus, ramis ultimis pallidioribus attenuatis, conspicue tortuosis denticulatisque; conidiis sphæricis, diu minutis

pallidis, dein fuligineis, 9·5–10 μ diam., levibus, ex denticulis orientibus. Hab. in foliis marcescentibus, in horto Bogoriensi. Javæ—Pulcra species ad *Streptotrichem* et *Botrytidem* accedens et ob hyphas sæpe densiuscule fasciculatas etiam ad *Graphium* nutans.—A *T. fusco* differt ramis crebrioribus, conidiis sphæricis, etc." Penzig and Saccardo's figure of *T. arborescens* is also reproduced herewith in Plate IV, Figs. 3, 4. I have not seen a specimen, but from a study of Penzig and Saccardo's description and figure, it appears to me that *T. arborescens* resembles *Hansfordia* spp. in the branching of the conidiophore and the production of conidia, etc., but differs from the latter in having the conidiophores aggregated to form distinct and conspicuous synnemata. Indeed, Penzig and Saccardo's remarks on their fungus (which is reproduced above) and the suggested affinity to *Graphium*, the reference in their description to "hyphis liberis v. fasciculato-connexis", and their figures all indicate that the fungus is best accommodated in the Stilbaceæ. Further, from the description it would appear that its systematic position in the Stilbaceæ would be under the Phæostilbeæ. A critical comparison of *Tharoopama trina* with Penzig and Saccardo's description and figure of *Trichosporium arborescens* indicates that both species are congeneric. *T. arborescens*, however, has much larger conidia than *Tharoopama trina* and may, therefore, be considered specifically distinct from the latter. Accordingly, *Trichosporium arborescens* is being transferred to *Tharoopama*:

Tharoopama arborescens (Penzig and Saccardo) Subramanian comb. nov.

Basonym.—*Trichosporium arborescens* Penzig & Saccardo, 1904, *Icones fungorum javanicorum*, p. 101, plate lxix, **3**; Saccardo, 1906, *Sylloge Fungorum*, **18**: 575.

17. *Umbellula terrestris* (Timonin) Morris, 1955, *Mycologia*, **47**: 602.

≡*Spicularia terrestris* Timonin, 1940, *Canad. J. Res.*, C, **18**: 314.

A collection of this interesting fungus was made by Professor Sadasivan and myself from the Nilgiris in 1953. The fungus forms effuse, somewhat bluish-green growth on the substratum. The repent vegetative hyphæ are brown, branched, septate and up to 6 μ broad. The conidiophores arise laterally from cells of the repent hyphæ. They are unbranched and simple, erect, mostly straight, septate, dark brown with the apical cell alone being sub-hyaline, slightly tapering towards the tip, terminating in a verticil of up to about 16 simple, hyaline, sterigma-like branches of more or less equal length, each of which in turn terminates in a somewhat globose or sub-globose tip bearing many (about 25–30 is usual) conidia produced singly on minute, short pegs. The conidia are oblong-ovate, two-celled, sub-hyaline to pale greenish-brown (bluish-green in mass), smooth-walled, not constricted at the septa, and with a somewhat mamillate basal scar indicating the point of attachment. The measurements of the various parts of the conidiophore and conidia are:

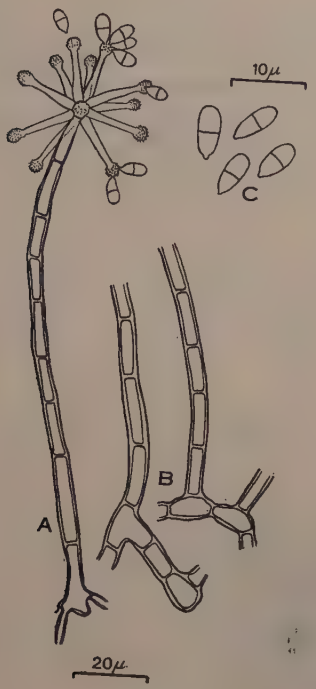

FIG. 17. *Umbellula terrestris* from Herb. M.U.B.L. No. 1050. A, conidiophore and conidia; B, basal portion of conidiophores; C, mature conidia.

Main stipe of the conidiophore.—Length up to 180 μ; breadth at the base 4·2–8·5 μ; breadth at the middle 6·0–7·7 μ; apical cell of the stipe 15·3–25·5×3·4 μ; distance between septa of the stipe up to 24 μ; sterigma-like branch 11·9–18·7×2·5–3·4 μ; diameter of globose tip of sterigma-like branch 3·4–5·1 μ.

Conidia.—6·8–7·7×2·5–3·4 μ.

Habit.—On dead stem, Coonoor (Nilgiris Disrtict, Madras State), 8–12–1953, coll. T. S. S. & C. V. S., Herb. M.U.B.L. No. 1050.

18. *Wiesneriomyces javanicus* Koorders, 1907, *Verh. Akad. Wet. Amst.*, **13** : 246, fig. 57; Saccardo, 1913, *Sylloge Fungorum*, **22**: 1496–97.

≡*Chætosira javanica* (Koorders) Clem., Clements, F. E., and Shear, C. L., *The Genera of Fungi*, p. 403.

A collection of this pretty fungus was recently made from the University Botany Laboratory campus, Madras. The fungus forms scattered sporodochia on the substratum. The sporodochia are dark in colour, cup-like, mostly with a narrow, short stipe, setose, 210–280 μ tall, 126–378 μ wide where they are broadest and 28–98 μ wide at the

base. The setæ are dark brown, slightly paler towards the apex, simple, erect, mostly bent in characteristic manner so as to have an inner concavity with reference to the sporodochium, long, up to 10-septate. the distance between septa being 14–51 μ, swollen and 7–11 μ thick at the base, 4·8–7·2 μ wide above, subulate with a somewhat pointed or blunt tip, and 126–266 μ long. Each sporodochium has

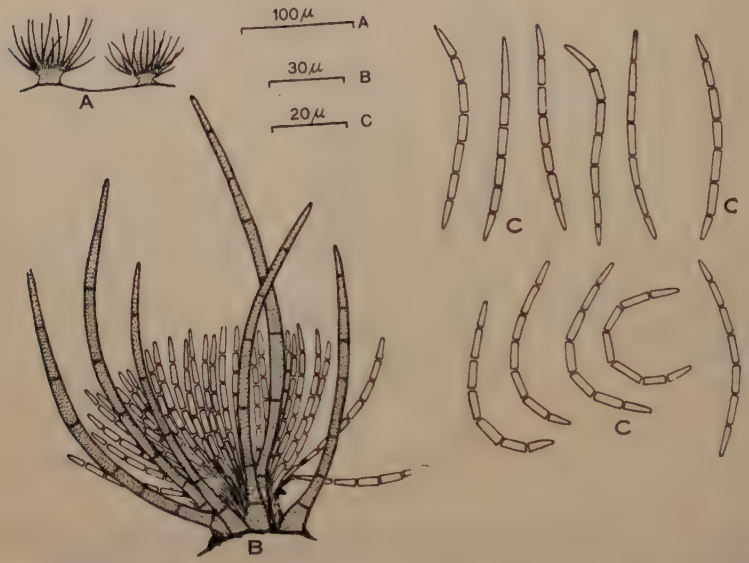

FIG. 18. *Wiesneriomyces javanicus* from Herb. M.U.B.L. No. 1418. A, B, aporodochia; C, conidia.

a varying number of setæ and up to 35 have been seen per sporodochium. The conidiophores arise from a dark brown stromatic base and are closely aggregated parallel to each other forming a hymenium surrounded by the sterile setæ. The conidiophores are simple, erect, cylindrical, non-septate, hyaline, 10–18 μ long and 2–3 μ broad. The conidia are produced singly and acrogenously at the tips of the conidiophores. They are hyaline to sub-hyaline, 5–7 (–11)-septate, somewhat filiform, being broadest in the middle, becoming slightly narrower towards the base and towards the apex, somewhat pointed at the apex, straight, slightly bent, falcate or curved, 49·3–69·7 μ long, and 2·5–3·4 μ wide where they are broadest. Each conidium at maturity often fragments into its individual cells or 2-more-celled pieces. The one-celled segments from the middle portion of the conidia are cylindrical and 7·6–17·0 μ long. The apical segments of the conidia are usually shorter, being 5·9–10·2 μ long.

Habit.—On dead leaves of *Cæsalpinia pulcherrima* Sw., in moist leaf litter, University Botany Laboratory campus, Madras, 9–11–1955, coll. K. Ramakrishnan, Herb. M.U.B.L. No. 1418.

My collection agrees largely with that figured and described by Koorders (1907) from Java and has, therefore, been assigned to *W. javanicus*. It would appear that this is the first time the fungus has been collected again since it was described by Koorders in 1907.

Clements and Shear (1931) have placed this genus under the Tuberculariaceæ-Amerosporæ, but I believe that the conidia are phragmospores which break up into 1-more-celled bits. Indeed, the fragmentation of the phragmospores into such bits may be considered a unique feature of the genus.

As pointed out by Bisby (1949, p. 14), "*Chætosira* is an invalid change, by Clements, of *Wiesneriomyces*", and the combination, *Chætosira javanica* (Koorders) Clements is invalid for the same reason.

Summary

Most of the hyphomycetes treated in this paper are from India. Four new genera are described: *Lomachashaka* (Tuberculariaceæ, Hyalosporæ) with the type species *L. kera* on dead leaves of *Cocos nucifera*, from Madras; *Paathramaya* (Stilbaceæ, Phæostilbeæ, Amerosporæ) with the type species *P. sundara* on dead stems, from Narsapur, Hyderabad-Deccan; *Prathoda* (Stilbaceæ, Phæostilbeæ, Scolecosporæ) with the type species *P. saparva* on dead stems, also from Narsapur; and *Tharoopama* (Stilbaceæ, Phæostilbeæ, Amerosporæ) with the type species *T. trina* on dead culms of grass, from Madras. *Trichosporium arborescens* Penzig & Saccardo, described from Java, is transferred to the new genus *Tharoopama*, as a second species.

Seven new species of hyphomycetes are described, also from India: *Annellophora indica*, on living leaves of *Photinia* sp., from Kodaikanal Hills; *Excipularia narsapurensis*, on dead wood, from Narsapur; *Exosporium coonoorense*, on dead stems, from Coonoor, Nilgiris; *Helicoceras longisporum*, on living leaves of *Celtis serotina*, also from Coonoor; *Helicomina indica*, on living leaves of a leguminous plant, from Castle Rock, Bombay State; *Spegazzinia sundara*, on dead bamboo, from Madras; and *Sporidesmium nilgirense*, on dead *Bambusa nana*, from Ootacamund, Nilgiris.

Spegazzinia tessarthra (B. & C.) Sacc. var. *deightonii* described by Hughes from the Gold Coast, Africa, is raised to specific rank. On the basis of a study of the type collection of *Helminthosporium arecæ* B. & Br. (Fungi of Ceylon No. 833) and of Indian collections of this fungus, it is concluded that Petch's disposition of this fungus under *Exosporium* is correct. *Exosporium pulchellum* Sacc. and *E. eximium* Sacc. are considered synonyms of *E. arecæ* (B. & Br.) Petch. *Helminthosporium guareicola* Stevens, *Umbellula terrestris* (Timonin) Morris and *Wiesneriomyces javanicus* Koorders are reported for the first time from India. Three other fungi mentioned are: *Spegazzinia tessarthra* (B. & C.) Sacc. and *Stigmina maculata* (Cooke) Hughes, the former being reported for the first time from the Madras State, and the latter from the Mysore State; and *Stigmina palmivora* (Sacc. *apud* Trelease) Hughes, from the Nilgiris.

Acknowledgments

I am deeply indebted to Professor T. S. Sadasivan, for much encouragement and to the Rev. Fr. Dr. H. Santapau, for kindly translating the generic and specific diagnoses into Latin; to Prof. V. Raghavan, for suggesting the new generic names in Sanskrit; to the Government Mycologist, Agricultural Research Institute, Coimbatore, and to the Head of the Division of Mycology, Indian Agricultural Research Institute, New Delhi, for specimens; and to the Director, Commonwealth Mycological Institute, Kew, England, for generous facilities provided for studies during my stay there in 1950–51. I thank the Ministry of Education, Government of India, for a grant-in-aid for travel which enabled me to collect several fungi reported in this paper.

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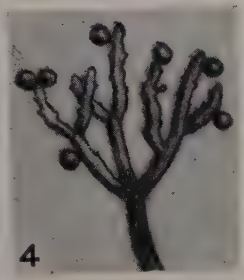
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EXPLANATION OF PLATE

Figs. 1–2. *Tharoopama trina.* Fig. 1. A synnema. Fig. 2. Part of conidiophores showing branching and production of conidia. Figs. 3–4. *Tharoopama arborescens*, reproduced from Penzig and Saccardo (1904). Fig. 3. A habit sketch showing the aggregation of conidiophores to form a synnema. Fig. 4. Showing the branching of the conidiophores and the production of conidia. Figs. 5–7. *Paathramaya sundara.* Fig. 5. A synnema. Figs. 6–7. Part of the fertile region of the synnemata showing the tips of conidiophores, the cup-like protuberances and the attachment of conidia. Figs. 8–9. *Prathoda saparva.* Fig. 8. Synnemata. Fig. 9. Apical fertile parts of synnemata showing the attachment of conidia to free ends of conidiophores and the phragmoscolecospores. Figs. 1, 8, ×75; Figs. 2,7, 9, ×320; Fig. 5, ×100; Fig. 6, ×200.

THE CLAVARIACEAE OF THE MUSSOORIE HILLS—I

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(Received for publication on August 6, 1955)

The Panjab University Botany Department has been undertaking a Botanical Excursion each year to the Mussoorie Hills, under the leadership of Prof. P. N. Mehra, to make a comprehensive study of the Cryptogamic Flora of that region. The taxonomic study of the Clavariaceæ is a part of the Fungal Flora under that programme.

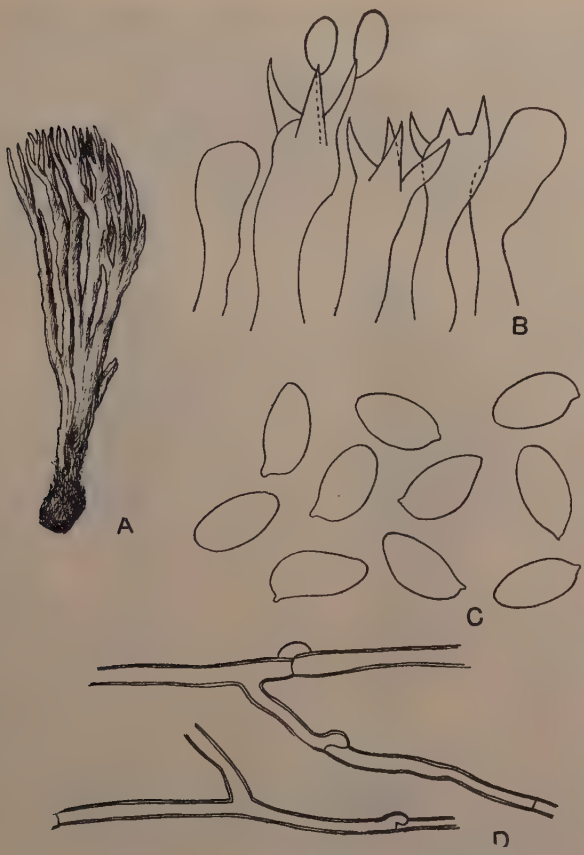
This interesting and most beautiful group of fungi has remained neglected so far in India. There have been only isolated reports of species by different people at different times. Thus until now only less than two dozen Clavarias have been reported and most of these are not adequately described. The present is the first attempt to study Indian Clavarias on a comprehensive scale. The classification recently proposed by Corner (1950) in his Monograph of Clavaria and Allied Genera has been followed in the present study.

This paper deals with the taxonomy of seven Clavarias which fall under 6 species and 1 form. One of these species belongs to the Thelephoroid Series while 5 species including 1 variety and 1 form belong to the Ramaria Series. All of these are new records for India. *Ramaria fumigata* (Pk.) Corner var. *gigantea* is proposed as a new variety. All these species are deposited in the Herbarium of the Panjab University.

Thelephoroid Series

1. *Aphelaria pusio* (B.) Corner

Fructifications gregarious, erect, small sized, flattened, with or without a trunk, branched, somewhat leathery and tough, whitish, 3·5–5 × 1–1·8 cm. Trunk, when present, 0·5–1·8 cm. long and up to 0·3 cm. broad. Branching dichotomous above and appearing polychotomous below due to very close dichotomy, branches unequal, flattened, fastigiate, in alternating planes, sometimes fused together. Apices concolorous and acute. Flesh concolourous. *Hymenium* spread all over except the trunk, up to 79 μ in width. *Basidia* clavate, subhyaline, 9–12 μ broad. Sterigmata 3–4, stout, and massive. *Basidiospores* subhyaline, oblong-ellipsoid, pip-shaped, smooth, thin-walled, aguttate when young, overmatured spores multiguttulate, guttules vague, 10·3–15·5 × 6–7·7 μ. *Hyphæ* monomitic, hyaline, narrow, branched, slightly thick-walled, septate, septa at long intervals, clamped, clamps abundant but not at all septa, 2·3–3·8 μ broad, hyphal cells up to 150 μ long, or even longer (Text-Fig. 1, A-D).



TEXT-FIG. 1. *Aphelaria pusio* (B.) Corner. A. Fructification, ×1. B. Basidia, ×880. C. Basidiospores, ×880. D. Slightly thick-walled hyphæ, ×330.

Collected on soil under oak forest, Kempty Road, Mussoorie, September 3, 1953, **25**.

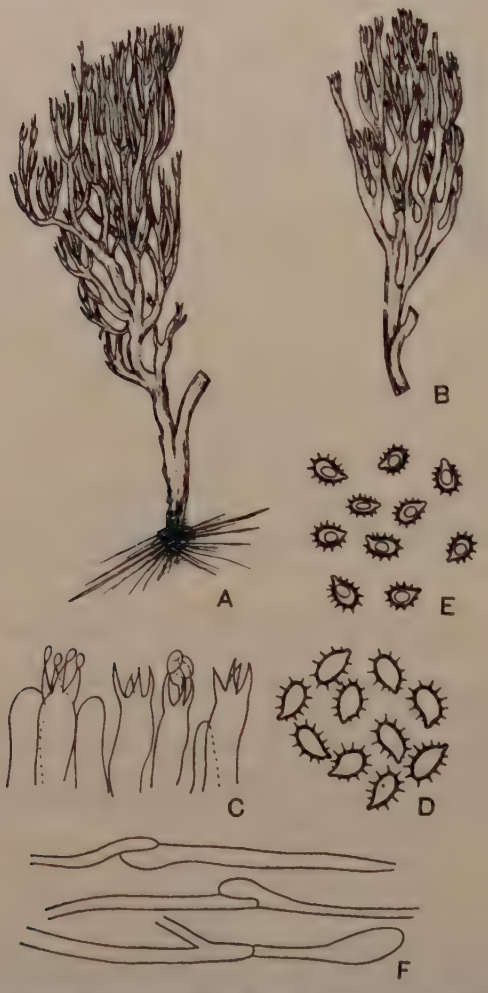
The fructifications of the present collection are slightly smaller but much more branched than those of *A. pusio* (B.) Corner (Corner, 1953). However, the size of the fruit body and degree of branching is often only a matter of age.

RAMARIA SERIES

2. *Ramaria flaccida* (Fr.) Ricken

Fructifications humicolous or lignicolous, gregarious, rarely solitary, medium sized, rarely large sized, radial, slender, flaccid, trunk absent, sometimes present, profusely branched, fleshy, smooth, glabrous, brown, dirty brown, or dirty yellowish brown, up to 7 cm. tall and up to 5 cm. broad, rarely up to 10 cm. tall and up to 6 cm. broad. Trunk, when present, slender, up to 1·7 cm. long and up to

3 mm. broad. Branching dichotomous, branches slender, unequal, in alternating planes, sometimes very small or ligulate, often fused with one another, ligulate or adventitious branches present all over the fructifications or confined to the basal part and they may also divide dichotomously and become bushy. Primary branches slender, only up to 2·5 mm. broad, ultimate branchlets thin, small, in equal or unequal pairs, sometimes minute and ligulate, very minute or 3–20 mm. long. Apices concolorous, acute, fertile. Flesh lighter coloured. Taste and smell inparticular. Numerous rhizomorphic mycelial threads



TEXT-FIG. 2. *Ramaria flaccida* (Fr.) Ricken.—A. Fructification of collection n. 28, ×1. B. A part of fructification n. 27, ×1. C. Basidia, ×880. D. Basidiospores of n. 27×1880. E. Similar and less conspicuouly marked spores of n. 28, ×880. F. Clamped hyphæ, ×30.

given out from the base of the fructification. *Hymenium* spread all over except the lighter coloured base, compound, with numerous embedded spores usually in clusters of four, 70–105 μ thick. *Basidia* clavate, 4–7 μ broad. Sterigmata four, slightly incurved, 3–6 μ long. *Basidiospores* brown, ellipsoid, papillate, profusely echinulate, wall dark, aguttate, 4–7 × 3–4 μ (see also Table I). *Hyphæ* monomitic, hyaline, branched, thin-walled, septate, septa at long intervals, not inflated, or sometimes slightly inflated, considerably swollen into sac-like structures at places near the ends or at the septa, clamped, clamps prominent, 2–8 μ broad (Text-Fig. 2, A-F).

Collected on humus under oak forest, The Park, Mussoorie, August 31, 1953, **26**. On dead leaves and dead twigs under oak forest, Chakrata Toll, Mussoorie, August 16, 1953, **27**. On dead pine needles under pine forest, The Park, Mussoorie, August 11, 1953, **28**. On humus under oak forest, Dhobi Ghat, Mussoorie, August 7, 1953, **29**.

Collections n. 27 and n. 29 are more typical of *Ramaria flaccida* (Fr.) Ricken than n. 26 and n. 28. The fructifications of n. 29 are the largest being up to 10 cm. tall and up to 6 cm. broad. Having seen a great many collections of *R. flaccida*, Corner (Personal correspondence, 1955) states that the fruit body of this species may grow up to 10 cm. high, or more, though commonly it is small.

Fructifications of n. 26 are solitary, flattened, sooty black, and with palmate branching. According to Corner (Personal correspondence, 1955) the palmate, or flattened branching of n. 26 is unusual (for *R. flaccida*) but occurs in some other species, *e.g.*, *Ramaria palmata* (Pers.) Quél., which is merely *Ramaria gracilis* (Fr.) Quél., with flattened branching.

Fructifications of n. 28 occur on pine needles and possess slightly smaller and less prominently marked spores. According to Corner (Personal correspondence, 1955) the small spores (see Table I) and habit on coniferous needles indicate *Ramaria myceliosa* (Pk.) Corner, but n. 28 may be only *R. flaccida*, because n. 26 and n. 29 seem to have as small spores. He is not sure if the two species (*R. myceliosa* and *R. flaccida*) are separable.

TABLE I

Spore-size in the four collections of Ramaria flaccida

Collection number	Spore size
26	4·6–6·4 × 2·5–3·8 μ
27	5·4–7 × 2·5–3·5 μ
28	4 –5·4 × 3–4 μ
29	4·6–6 × 3–4 μ

3. *Ramaria stricta* (Fr.) Quél. var. *concolor* Corner

Fructifications lignicolous, gregarious, cæspitose, erect, medium sized, radial, without a trunk, profusely branched, fleshy, smooth, glabrous, dark brown, or pinkish brown to violaceous brown, up to 8·5 cm. tall and up to 5 cm. broad. Branching more or less polychotomous below and dichotomous above, branches crowded, often fused together, unequal, in alternating planes, internodes long, primary branches up to 3 mm. broad, ultimate branchlets very thin or slender, from very small to 0·6–1·3 cm. long. *Apices* cream coloured to yellowish, or concolorous, acute. Flesh concolorous. Taste and smell inparticular. Numerous long rhizomorphic mycelial strands given out from the bases of fructifications. *Hymenium* spread all over except the white submerged base, thickening, stratose, with abundant embedded spores, up to 345 μ broad. *Basidia* clavate, subhyaline to pale brown, 7–9 μ broad. Sterigmata 4, rarely 2–3, stout, slightly incurved, 3·5–7 μ long. *Basidiospores* light brown, broadly ellipsoid, papillate, rough, or almost smooth, wall dark, aguttate or uniguttate, guttule large and filling $\frac{1}{3}$–$\frac{1}{2}$ of the spore cavity, rarely 2–3 guttulate, 7–10·5×4–6·7 μ. *Hyphæ* monomitic, hyaline, slightly to moderately thick-walled, sometimes much thickened, thickening 0·5–1·6 μ, branched, not inflated, septate, septa at long intervals, clamped, H-pieces present,

TEXT-FIG. 3. *Ramaria stricta* (Fr.) Quel. var. *concolor* Corner. A. Fructification, ×1. B. Basidia, ×880. C. Basidiospores, ×880. D. Thick-walled and clamped hyphæ, ×380.

highly convoluted and interwoven, often swollen at ends or near septa, 2–12 μ broad, up to 16 μ broad at the swollen regions (Text-Fig. 3, A-D).

Collected on rotting stumps and logs of trees in oak forest, The Park, Mussoorie, August 13, 1953, **30**. On humus amid mosses and on dead leaves of *Quercus incana* Roxb. under oak forest, The Park, Mussoorie, August 9, 1953, **31**.

According to Corner (Personal correspondence, 1955) violaceous tints, as we have observed in collection n. 31, may develop in the species *R. stricta*.

4. *Ramaria stricta* (Fr.) Quél. var. *concolor* Corner "Dark Coloured Form"

Fructifications lignicolous, solitary, erect, medium sized, radial, without a trunk, profusely branched, fleshy, smooth, glabrous, sooty black, up to 7 cm. tall and up to 5·8 cm. broad. Branching polychotomous below, dichotomous above, branches unequal, in alternating planes, compact, fused together at places, primary branches up to 4 mm. broad, ultimate branchlets minute, only up to 3 mm. long, in pairs, or look crowded and cristate due to very close and irregular dichotomy. Branches lighter coloured above. Apices lighter coloured or cream coloured and blunt. White rhizomorphic branches given out from the base of the fructifications. Flesh concolorous. Taste and smell inparticular. *Hymenium* spread all over, compound, stratose, 140–175 μ thick. *Basidia* clavate, brown or pale brown, 6·3–7·4 μ broad. Sterigmata 4, 3·5–7 μ long. *Basidiospores* light or pale brown

TEXT-FIG. 4. *Ramaria stricta* (Fr.) Quel. var. *concolor* Corner "Dark coloured form."—A. Basidia, ×880. B. Basidiospores, ×880. C. Considerably thick walled and clamped hyphæ, ×380.

to brown, ellipsoid, papillate, rough or inconspicuously verrucose, warts not distinct, wall dark, aguttate or with 1–3 or more vague guttules, 7–11×3·5–5 μ, abundantly embedded in the compound hymenium. *Hyphæ* monomitic, subhyaline, branched, septate, septa at long intervals, clamped, 2·58–8·6 μ broad, thick-walled (skeletal), wall 0·86–5·16 μ thick, thickening often highly pronounced so as to obliterate whole of the lumen (Pl. V, Fig. 1; Text-Fig. 4, A-C).

Collected on fallen dead pine needles, The Park, Mussoorie, September 2, 1953, **32.**

This collection resembles *Ramaria stricta* (Fr.) Quél. var. *concolor* Corner in all respects except that its fructifications are very dark and sooty black. Therefore, as suggested by Corner (Personal correspondence, 1955) this collection n. 32 is regarded as a dark coloured form of the variety *concolor* Corner.

5. *Ramaria subbotrytis* (Coker) Corner

Fructifications solitary, erect, large sized, radial, without a trunk, profusely branched, fleshy, smooth, glabrous, deep scarlet red or deep pinkish red when young, colour fading at maturity, up to 10 cm. tall and up to 10 cm. broad. Base stubby, thick, lighter coloured. Branching polychotomous below but dichotomous above, branches compact, unequal, in alternating planes, primary branches up to 1 cm. broad, ultimate branchlets small to minute, thin. Apices obtuse or blunt, in pairs, or crowded together and looking cristate due to close dichotomy, concolorous. Flesh concolorous. Taste and smell inparticular. *Hymenium* spread all over, compound, up to 74 μ broad. *Basidia* clavate or elongated, light brown or subhyaline, 5–7·4 μ broad. Sterigmata 4, long, straight or slightly incurved, 3·5–5·3 μ long. *Basidiospores* light violet or light brownish violet when in a mass, brown or sooty brown individually under the microscope, narrowly ellipsoid, papillate, wall dark, rough to almost smooth, aguttate, abundantly embedded in the compound hymenium, 7–9·8×3·5–4 μ. *Hyphæ* monomitic, hyaline or subhyaline, thin-walled, inflated, may be slightly constricted at the septa, septate, septa at shorter intervals, secondary septa absent, clamps absent, 3·5–14 μ broad, hyphal cells 67–121 μ long (Text-Fig. 5, A-D).

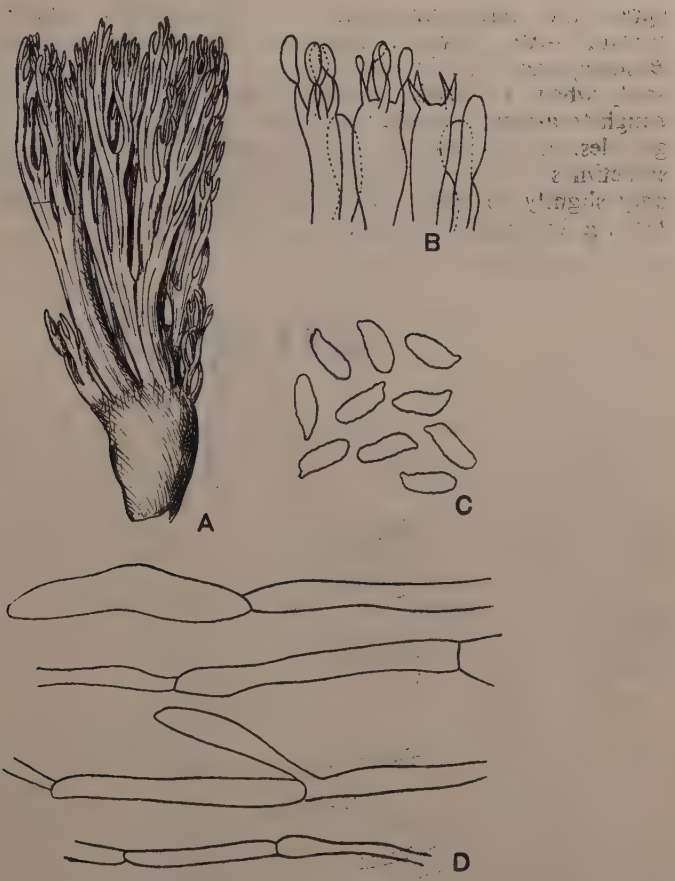
Collected on soil under oak forest, Chakrata Toll, Mussoorie, August 6, 1953, **33.**

This species is easily recognized from the red colour, the small and narrow spores, and the absence of clamps.

6. *Ramaria fumigata* (Pk.) Corner var. *gigantea* var. nov.

Usque 21·5 cm. alta, carne color immutatus, sporis 10·5–14 ×4·2–6·3 μ, hyphis fibulis præditis. Terrestris, Chakrata Toll, Mussoorie, India, August 20, 1953, **34.**

Up to 21·5 cm. high, flesh not changing colour on bruising, spores 10·5–14×4·2–6·3 μ, hyphæ provided with clamps.

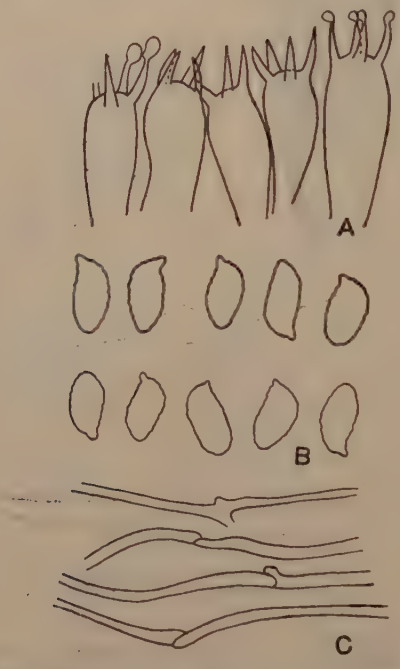


TEXT-FIG. 5. *Ramaria subbotrytis* (Coker) Corner.—A. Fructification, ×1. B. Basidia, ×880. C. Basidiospores, ×880. D. Inflated hyphæ, ×380.

Collected on soil, Chakrata Toll, Mussoorie, India, August 20, 1953, **34**.

Fructifications gregarious or solitary, erect, large sized, massive, radial, trunk present, profusely branched, fleshy, smooth, glabrous, violet coloured throughout, colour fading in over-matured specimens to fuliginous ochraceous but the tips remain violet for a longer time, up to 21·5 cm. tall and up to 10 cm. broad. Trunk as undifferentiated stubby basal part of the fructification, up to 5·8 cm. broad. Branching polychotomous below and dichotomous above, branches crowded to compact, unequal, in alternating planes, primary branches up to 1 cm. broad, ultimate branchlets minute, blunt and crowded together due to close dichotomy. Flesh white to cream coloured, not changing colour on bruising. Taste and smell inparticular. Internodes are generally long but they may be short in some specimens. *Hymenium*

spread all over, compound, up to 88 μ broad. *Basidia* clavate, pale brown, 8–10·5 μ broad. Sterigmata 4, slightly incurved, 3·5–7 μ long. *Basidiospores* light brown to brown or sooty brown, dark brown to sooty when in a mass, narrowly ellipsoid to broadly ellipsoid, papillate, rough to almost smooth, wall dark, aguttate or with one or more vague guttules, 10·5–14×4·2–6·3 μ. *Hyphæ* monomitic, subhyaline, branched, sometimes antler-like short branches also observed, not inflated or only slightly so, thin-walled septate, septa at long intervals, clamped, 1·8–7 μ broad (Pl. V, Fig. 2; Text-Fig. 6, A-C).



TEXT-FIG. 6. *Ramaria fumigata* (Pk.) Corner var. *gigantea* var. nov.—A. Basidia, ×880. B. Basidiospores, ×880. C. Clamped hyphæ, ×380.

Collected on soil under oak forest, Chakrata Toll, Mussoorie, August 20, 1953, **34.**

This collection comes near to *Ramaria fumigata* (Pk.) Corner but it differs from the latter in the following important respects:—

Present collection	*R. fumigata*
1. Up to 21·5 cm. tall.	1. 5–12 cm. tall.
2. Primary branches upto 1 cm. broad.	2. Primary branches only 2–3 mm. broad.
3. Not rufescent on bruising.	3. Rufescent on bruising.

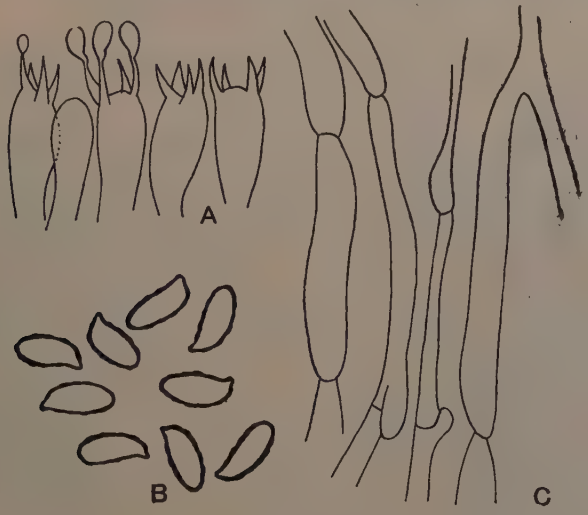
4. Spores aguttate or with 1 to more vague guttules.	4. Spores uniguttate.
5. Hyphæ clamped.	5. Hyphæ not clamped.
6. Spores 10·5–14×4·2–6·3 μ	6. Spores 8·5–12·5×3·7–5·5 μ.

As also suggested by Corner (Personal correspondence, 1955), the collection n. 34 is regarded here as a new variety on the basis of its very large fructifications, the larger spores, the absence of colour change of the flesh, and the presence of clamps on the hyphæ. The name var. *gigantea* is proposed because of its larger size and slightly larger spores.

7. *Ramaria obtusissima* (Pk.) Corner

"Rough Spored Form"

Fructifications solitary, erect, large sized, radial, trunk present, profusely branched, fleshy, smooth, glabrous, cream coloured, deep coloured below and lighter coloured at the top, up to 14 cm. tall and up to 11 cm. broad. Trunk narrow, up to 2 cm. long and 1 cm. broad. Branching dichotomous, branches rather lax, unequal, in alternating planes, internodes long below but shorter above, primary branches like the trunk and up to 0·9 cm. broad, ultimate branchlets very small to 3 mm. long, in pairs, or crowded together and look cristate due to close dichotomy. Apices obtuse or blunt, concolorous. Flesh whitish. Taste bitter, smell inparticular. *Hymenium* spread all over except the trunk, compound, 73–112 μ broad. *Basidia* clavate, light brown,



TEXT-FIG. 7. *Ramaria obtusissima* (Pk.) Corner "Rough spored form". A. Basidia, ×880. B. Basidiospores, ×880. C. Inflated and clamped hyphæ, ×380.

7–10·5 μ broad. Sterigmata 2–4, 3·5–7 μ long. *Basidiospores* light brown, ellipsoid, papillate, slightly rough, wall dark, aguttate, abundantly

embedded in the compound hymenium, 10·5–15×4·0–6·0 μ. *Hyphæ* monomitic, hyaline to subhyaline, branched, thin-walled, inflated, hyphæ may be swollen at ends, ends of the hyphal cells gliding over one another, clamps present, septate, septa at short to long intervals, hyphal cells 3·5–15 μ broad and from 32 μ to very long (Pl. V, Fig. 3; Text-Fig. 7, A-C).

Collected on soil under oak forest, Chakrata Toll, Mussoorie, August 6, 1953, **35.**

The spores of this collection are slightly rough and wider than *Ramaria obtusissima* (Pk.) Corner which has characteristically smooth and narrowly-cylindrical spores (10–15×3·5–5 μ). Accordingly, collection n 35 is put under the "rough spored form" of this species.

Acknowledgments

The writers are deeply indebted to Mr. E. J. H. Corner, F.R.S., of the Botany School, Cambridge, England, for help in the identification of the species and Prof. P. N. Mehra for valuable criticism and encouragement. They are also thankful to Mr. Balram Khanna for making illustrations of the fructifications apart from the photographs.

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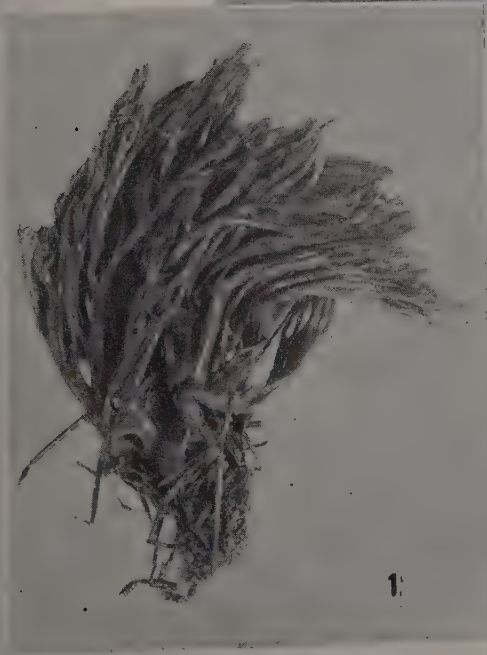
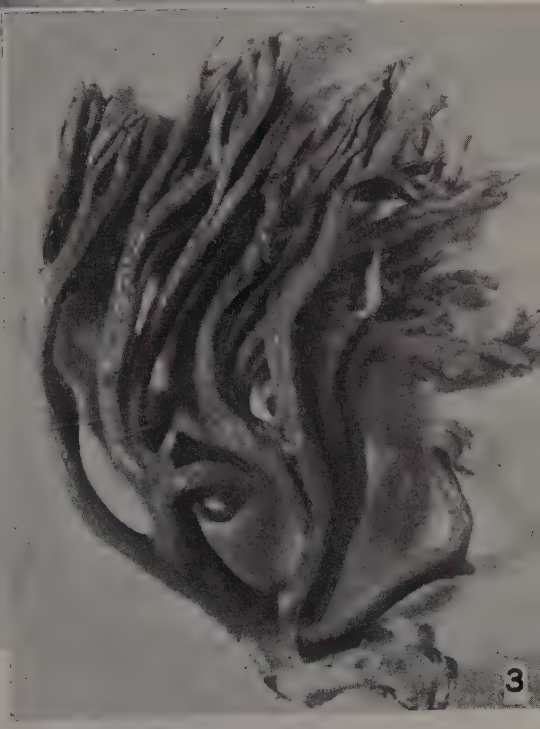
Explanation of Plate

Fig. 1. *Ramaria stricta* (Fr.) Quél var. *concolor* Corner "Dark Coloured Form".

Fig. 2. *Ramaria fumigata* (Pk.) Corner var. *gigantea* var. nov.

Fig. 3. *Ramaria obtusissima* (Pk.) Corner "Rough Spored Form".





K. S. Thind and G. P. S. Anand

ON TWO NEW SPECIES OF *TERMINALIOXYLON* SCHÖNFELD FROM THE TERTIARY OF SOUTH ARCOT DISTRICT, MADRAS

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(Received for publication on October 10, 1955)

Introduction

The present paper deals with two new species of *Terminalioxylon* Schönfeld, collected by the author in 1952 from near Murttanqi (also known as Mortandra) and Tiruchhitambalam, about 5 and 7 miles W.N.W. of Pondicherry respectively, in South Arcot District, Madras. The fossiliferous localities can be reached from Tindivanam on the Southern Railway. Both Mortandra and Tiruchhitambalam are on the bus route from Tindivanam to Pondicherry. Besides silicified trunks which dominate the landscape, hardly any other organic remains are found at these areas; the only other fossils to be met with here are of some gasteropods.

The whole area is a plain, dotted with hillocks not more than 100 feet in height, with ridges, caves and ravines. The hillocks are formed of Cuddalore sandstones. The silicified trunks occur firmly embedded in these sandstones, but a considerable number of them have been loosened by weathering and lie scattered freely on the ground (Pl. V1, Fig. 1).

The Cuddalore sandstones to which the fossil trunks belong are formed of argillaceous and silicified sandstones with lumps and veins of chert. These sediments lie along the east coast and overlie various coastal deposits of Mesozoic age. A variously coloured and mottled loose textured sandstone is the principal component of these rocks. The age of the Cuddalore sandstones is believed to range from the Eocene to Pliocene (Sahni, 1931). Krishnan (1949) regards the Cuddalore sediments to be of Miocene and according to Wadia (1953) a great part of this series is believed to be of Pliocene age and the other parts to be of still younger age.

From the same fossiliferous localities the author briefly reported previously (Ramanujam, 1953, 1954 *a*) dicotyledonous trunks belonging to various other families like Guttiferæ, Dipterocarpaceæ, Celastraceæ, Anacardiaceæ, Leguminosæ, Sonneratiaceæ, and Euphorbiaceæ, and very recently (Ramanujam, 1954 *b*) has described in detail the anatomy of two fossil trunks belonging to the family Leguminosæ showing similarities in particular to the genera *Cæsalpinia* and *Acacia*. The author is not aware of any published records of fossil trunks from India resembling the modern genus *Terminalia* belonging to the family Combretaceæ, consequently the present report of the occurrence of

such fossil trunks in the Tertiary rocks of South Arcot District is the first of its kind from India.

Material and Methods

The specimens collected are from large trunks generally 1–2 feet in diameter and 3–5 feet in length. The fossils are finely silicified and range in colour from greyish to deep brown. For each wood studied several transverse, tangential and radial sections were made. The sections were generally thinly ground, but at times somewhat thicker sections proved to be useful for studying the gross structures of the fossils. The examination of the polished transverse surface of the wood in reflected light was of paramount help in studying the distribution of the vessels and the xylem parenchyma. The thin sections were examined as a rule under glycerine, but where there was no danger of their becoming transparent they were mounted in canada balsam. The sections usually were not stained as the natural stain of the petrifacation made the tissues fairly prominent. Comparisons were made as far as possible with the modern specimens.

Terminalioxylon Shönfeld

Terminalioxylon speciosum sp. nov.

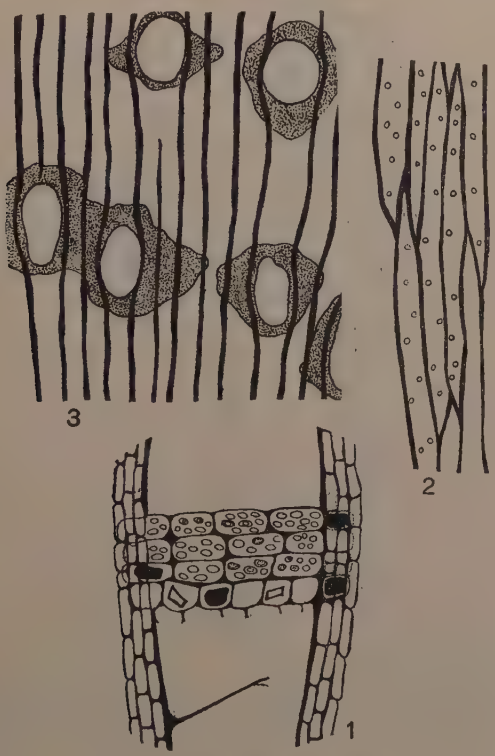
The species is represented by about 12 pieces of silicified wood. The figured specimen measures 10×5 cm. The wood shows very good preservation.

No growth rings are seen either by the naked eye or under the microscope. The vessels are diffuse and can be seen by the unaided eye as light coloured dots against the grey background of the fossil. They are solitary and arranged without any definite pattern. They are medium to large, comparatively thin-walled and oval to rounded in the cross-section. The vessels frequently deflect the xylem rays. The majority of the vessels are abundantly tylosed, but the tyloses are sometimes masked by dark contents which fill the vessels. The vessel-segments are medium, and truncate or sometimes attenuately tailed at one or both ends. The perforations are exclusively simple, horizontal or slightly oblique. The intervessel pits are numerous and in general are fairly large, circular to elliptic in outline, prominently bordered and vestured (Pl. VI, Fig. 2). Their distribution is usually alternate, although in certain parts of the facets an opposite alignment may be retained. The vessel-ray pitting is more or less similar to the intervessel pitting. The vessel-ray pits, however, tend to be slightly larger than the corresponding intervessel pits; they are 3–8 per cell and arranged irregularly (Text-Fig. 1). The vessel-parenchyma pits are bordered and alternate; they are rounded to flattened with circular apertures.

The fibres are well preserved. As seen in transverse sections they are arranged in more or less regular radial rows which are frequently interrupted by the paratracheal parenchyma. They are squarish to rectangular in outline as seen in cross-sections. The fibres are distinctly libriform and medium in length. They are always aseptate.

Interfibre pits are few, simple and circular; these pits are usually very minute and inconspicuous (Text-Fig. 2).

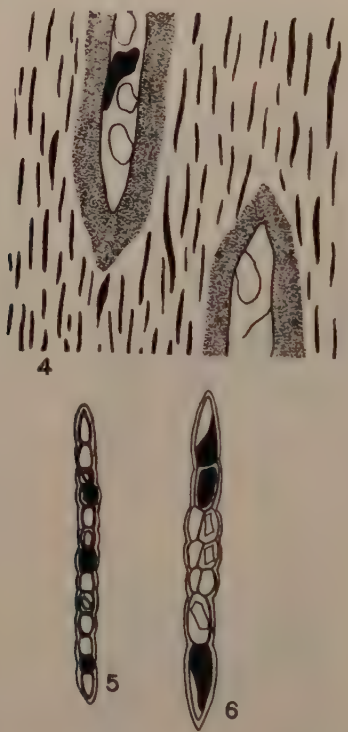
On the whole the xylem parenchyma is abundantly developed. It is visible to the naked eye in the immediate vicinity of the vessels as light coloured patches. It is of two types: (1) paratracheal and (2) apotracheal. The paratracheal parenchyma is represented by 2–6 cells thick vasicentric to aliform sheaths (Text-Fig. 3; Pl. VI, Figs. 3, 4). The aliform parenchyma at times tends to become confluent. The distribution of the apotracheal parenchyma is purely diffuse, consisting of either single cells or groups of cells numbering 1–3 scattered irregularly among the fibres; from fibres they can be easily distinguished by their larger size and thin-walled nature. The parenchyma cells in general are oval to round and are occasionally filled with some dark brown contents. Pits to the parenchyma cells are invariably simple, circular to elliptical and numerous (Text-Fig. 3).



TEXT-FIGS. 1–3. *Terminalioxylon speciosum* sp. nov. Fig. 1. Vessel-ray pitting. ×200. Fig. 2. Pits to the fibres, ×200. Fig. 3. Semi-diagrammatic cross-section to show the distribution of the parenchyma (stippled), ×45.

The rays are numerous and very closely spaced; they appear on the polished transverse and tangential surfaces of the fossil wood as

fine lines under the hand lens. The rays are evenly distributed (Text-Fig. 4). They are 1–2 seriate. The uniseriate rays are predominant and the biseriate ones occur fairly commonly (Pl. VI, Fig. 5). In height the rays range from 2–25 cells. They are weakly heterogeneous with 1–2 marginal rows of square or vertical cells (Text-Figs. 5, 6). The uniseriate rays often contain almost entirely of either procumbent or vertical cells. A very important feature of the xylem rays is the presence of crystalliferous cells in them, each cell containing a single large crystal. The crystals are found mostly in the procumbent cells, but they occur frequently in the vertical cells also (Text-Figs. 5, 6). In addition to the crystals a dark coloured deposit fills most of the ray cells. Pits to the tangential walls of the ray cells is not observed.



TEXT-FIGS. 4–6. *Terminalioxylon speciosum* sp. nov. Fig. 4. Semi-diagrammatic tangential section to show the distribution of the xylem rays, ×45. Fig. 5. A uniseriate ray, ×200. Fig. 6. A biseriate ray. Note the crystalliferous cells, ×200.

Comparison with the living species.—The fossil wood from Mortandra shows the following important features that are of very great help in its identification: (1) vessels medium to large, solitary, (2) vestured pitting of the vessels, (3) aseptate, libriform fibres, (4) parenchyma abundant, paratracheal and diffuse, and (5) 1–2 seriate weakly hetero-

geneous rays, with cells containing single crystals. The presence of these characters necessitates one to compare the fossil with the members of the families like Anacardiaceæ, Urticaceæ, Leguminosæ, and Combretaceæ (Gamble, 1922; Pearson and Brown, 1932; Metcalfe and Chalk, 1950). Anacardiaceæ and Urticaceæ have some genera which show a superficial resemblance with our fossil, but these families markedly differ from the fossil in the nature of the xylem rays and the intervessel pitting which, in these two families, is not vestured.

In Leguminosæ some species of *Acacia* and *Albizzia* show resemblances to the fossil in the distribution of the xylem parenchyma, and to some extent in the nature and arrangement of the vessels. But they fundamentally differ in other important characters. Thus in both these genera the rays are much different, being wider, always homogeneous and without crystalliferous cells. The parenchyma in *Acacia* and *Albizzia*, is crystalliferous. Besides, in both these genera, the vessels are not tylosed and the intervessel pits are minute and inconspicuous.

In its vestured intervessel pits, and crystalliferous ray cells coupled with the other important characters, the present fossil shows the greatest resemblance with the members of the Combretaceæ. There are several species, particularly those of *Terminalia*, which show many similarities with our fossil. The following species of *Terminalia* were compared *viz.*, *T. tomentosa*, *T. catappa*, *T. belarica*, *T. paniculata*, and *T. oblongata*. From a study of the wood anatomy of these species it is seen that the generic resemblances of the South Indian fossil with *Terminalia* are very strong and unmistakable. This is shown by a close similarity between the two in characters such as the size, shape and arrangement of the vessels, in the nature of the pitting on the various types of cells, in the nature and distribution of the xylem parenchyma, and last but not the least in the structural details of the xylem rays.

Comparison with the fossil species.—In 1936 Rode described a dicotyledonous wood *Dryoxylon mohgaænse*, from Deccan Intertrappean series showing according to him, its nearest affinity to the members of Combretaceæ. Since this is all what is represented by Combretaceæ in the Indian rocks so far, a detailed comparison has been made with Rode's species. Our fossil differs from *Dryoxylon mohgaænse*, in more than one respect. Thus in the South Indian fossil xylem parenchyma is abundantly represented as against the very scanty parenchyma of the latter, growth rings are absent as against the fairly distinct growth rings of *D. mohgaænse*, and the xylem rays contain crystalliferous cells as against their complete absence in the Deccan Intertrappean species.

Schönfeld in 1947 described two species of fossil woods from the Tertiary of Columbia resembling the modern species of *Terminalia*. These are *Terminalioxylon naranjo* and *T. porosum*. Both these species despite possessing many features similar to our fossil are, however, easily distinguishable from it. In *Terminalioxylon naranjo* besides paratracheal parenchyma short tangential strips of apotracheal parenchyma are always present; secondly the rays are nearly always uniseriate. In our fossil there are no tangential strips of apotracheal

parenchyma and the biseriate rays are fairly common. In *Terminalioxylon porosum*, in contrast with the South Indian fossil, the vessels are much bigger and frequently distributed in radial groups of 2–9; moreover the rays in the Columbian species are very high (5–80 cells high).

The present fossil wood as it differs from the hitherto described species in one or another important character has been given a new specific name, *Terminalioxylon speciosum*.

Diagnosis.—A diffuse porous wood.

Growth rings not present.

Vessels distinct to the naked eye, solitary, radial groups not seen. Diffuse, 10–12 per square mm., oval to round. Medium to large, 180–270 μ in diameter. Majority abundantly tylosed. Vessel-segments medium, 250–750 μ long, truncate or sometimes attenuately tailed at one or both ends. Perforations simple, horizontal or slightly oblique. Intervessel pits fairly large, prominently bordered, vestured, circular to elliptic in outline; usually alternate. Vessel-ray pitting similar to intervessel pitting; vessel-ray pits 3–8 per cell, arranged irregularly. Vessel-parenchyma pits bordered, alternate, rounded to flattened with circular apertures.

Fibres libriform. Medium, 1100–1300 μ in length, 18 μ in diameter. Arranged in regular radial rows frequently interrupted by paratracheal parenchyma. Squarish to rectangular in cross-section. Aseptate.

Parenchyma abundant. Paratracheal and apotracheal. Paratracheal in 2–6 cells thick vasicentric to aliform sheaths; sometimes aliform sheaths tend to become confluent. Distribution of apotracheal parenchyma diffuse, either in single cells or groups of 1–3 cells scattered irregularly among the fibres. Parenchyma cells oval to round 25–40 μ in diameter, often filled with dark brown contents. Pits simple, circular, numerous per cell.

Xylem rays numerous, 15–20 per mm. evenly distributed. 1–2 seriate, Uniseriate rays predominant, biseriate rays fairly common. 2–25 cells high, weakly heterogeneous with 1–2 marginal rows of square or vertical cells. Most of the ray cells contain a single crystal; usually procumbent cells crystalliferous, sometimes vertical cells too contain single crystals.

Holotype.—No. 4973. The type specimen and the slides are kept in the Museum of Birbal Sahni Institute of Palæobotany, Lucknow.

Localities.—Mortandra and Tiruchhitambalam.

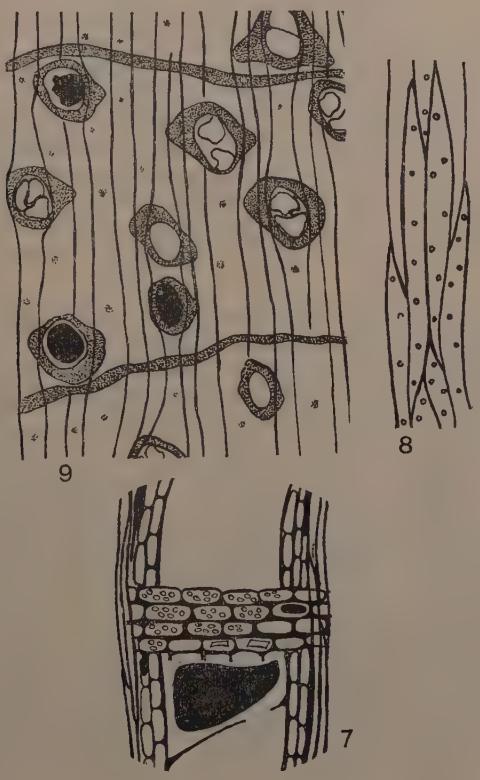
Terminalioxylon Felixi sp. nov.

The fossil is represented by about 5 small silicified wood pieces greyish in colour with light yellow or brown patches here and there.

This wood is similar in general characters to the one previously described, but differs from it in certain features of specific value.

The growth rings are rather indistinct, but the lines of demarcation between them can be seen clearly due to the presence of narrow bands of initial parenchyma.

The vessels are diffuse and appear to the naked eye as whitish dot-like structures against the grey background of the fossil. They are mostly solitary and circular, but radial groups of 2–3 are seen occasionally. When in radial groups the vessels are flattened at the points of contact. They are medium in size, and frequently tylosed. The vessel-segments are medium and truncate. The perforations are simple and horizontal or slightly inclined. The intervessel pits are fairly large, bordered, alternate and distinctly vestured. The pits are either rounded or flattened. The vessel-ray pits are bordered, rounded or tangentially stretched, 2–6 per cell arranged irregularly; the pit apertures are circular or, more or less, lenticular (Text-Fig. 7). The vessel-parenchyma pits are numerous, bordered and rounded to elliptical with circular apertures.



TEXT-FIGS. 7–9. *Terminalioxylon Felixi* sp. nov. Fig. 7. Vessel-ray pitting ×200. Fig. 8. Pits to the fibres, ×200. Fig. 9. Semi-diagrammatic cross-section to show the distribution of the parenchyma (stippled). ×45.

The fibres are libriform. They are considerably thick-walled and usually medium in length. They are in general distributed in radial seriations as seen in cross-sections and squarish to polygonal in outlines. The fibres as a rule are aseptate. The pitting to the fibres is very distinctly seen in tangential sections; the pits are simple, rather small, and circular (Text-Fig. 8).

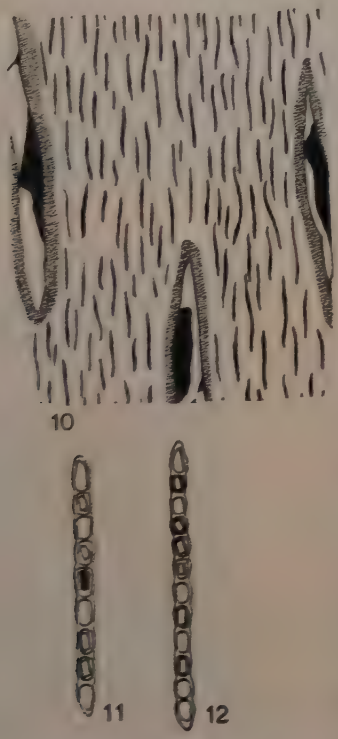
The parenchyma in contrast with *Terminalioxylon speciosum* is limited in amount. It is paratracheal and apotracheal and is visible to the naked eye as buff-coloured patches. The paratracheal parenchyma is represented by vasicentric to aliform sheaths, 1–3 cells thick (Text-Fig. 9; Pl. VII, Fig. 8). The aliform sheaths in this species never become confluent. The apotracheal parenchyma consists of narrow, 1–3 cells thick initial bands (Text-Fig. 9; Pl. VII, Fig. 7), and also as diffuse cells or groups of cells. The initial bands of apotracheal parenchyma appear to the naked eye as growth marks. According to Chowdhury (1936, 1953) parenchyma bands occurring in between growth rings are distinguishable into two types: (1) terminal, representing parenchyma formed at the end of the season's growth, and (2) initial, which means parenchyma formed at the beginning of the season's growth. The difference between these two types lies in the size, and shape of their cells. "As a rule, the terminal type is radially flattened and rectangular in shape, while the initial shows variation in shape, from rectangular to triangular but for the most part widest radially" (Chowdhury, 1936). On the basis of this difference the parenchyma bands in the South Indian fossil wood appear to be of the initial type and not terminal. The parenchyma cells in general are round to oval, and are empty. Pits to the parenchyma cells are seen very clearly in the tangential sections; the pits are always simple, circular and rather small.

The xylem rays appear as extremely fine lines under the hand lens. They are numerous and distributed evenly throughout (Text-Fig. 10). In contrast with the previous species they are here almost exclusively uniseriate (Pl. VII, Fig. 9), and rays showing the biseriate condition are very sporadic. The rays are 2–20 cells high and are usually homogeneous (Pl. VII, Fig. 11); rarely they are weakly heterogeneous with a single row of marginal vertical cells. When homogeneous the rays contain either entirely procumbent cells or vertical cells. The ray cells in general contain a single crystal (Text-Figs. 11, 12; Pl. VII, Fig. 10). These crystalliferous cells are more or less conspicuous in the tangential sections. In addition to the crystals the ray cells sometimes contain a dark brown deposit.

Comparison with the fossil species.—Terminalioxylon Felixi differs from *Terminalioxylon speciosum*, in the former's (1) smaller vessels, (2) relatively less parenchyma, in the form of initial bands and vasicentric to aliform sheaths, and (3) almost exclusively uniseriate xylem rays which are usually homogeneous.

The present species when compared to *Terminalioxylon naranjo* and *T. porosum* (Schönfeld, 1947) described from the Tertiary of Columbia, shows several marked differences. It differs from both the

South American species in possessing smaller vessels, and limited amount of parenchyma. In both *T. naranjo* and *T. porosum*, the aliform parenchyma at many places becomes confluent, while in our specimen confluent parenchyma is absent. The above fossil woods from Columbia have no initial parenchyma, although short strips of apotracheal parenchyma are seen in *Terminalioxylon naranjo*. Our fossil, however, resembles *T. naranjo*, in the xylem rays. In *T. porosum*, the rays although similar to our fossil in other characters, are very high (5–80 cells).



TEXT-FIGS. 10–12. *Terminalioxylon Felixi* sp. nov. Fig. 10. Semi-diagrammatic tangential section to show the distribution of the uniseriate xylem rays, ×45. Figs. 11, 12. Uniseriate rays. Note the crystalliferous cells, ×45.

The present fossil wood is named after Felix, as *Terminalioxylon Felixi*, who is one of the pioneer workers on fossil dicotyledonous woods. Felix, incidentally redescribed Schleiden's *Peuce Schmidianum*, from Tiruvakkarai village which is very near to Mortandra and Tiruchhitambalam in South Arcot District, and has also given a short geological sketch of the fossiliferous localities at and near about Tiruvakkarai (Felix, 1882).

Diagnosis.—A diffuse porous wood.

Growth rings rather indistinct.

Vessels visible to the naked eye as whitish dot-like structures. Diffuse 10–16 per square mm. Mostly solitary, circular, occasionally in radial groups of 2–3. Medium sized, 130–250 μ in diameter. Frequently tylosed. Vessel-segments medium, 300–800 μ, truncate. Perforations simple, horizontal or slightly inclined. Intervessel pits fairly large, bordered, distinctly vestured, alternate, rounded or flattened. Vessel-ray pits bordered, rounded or tangentially stretched, 2–6 per cell, arranged irregularly; pit apertures circular, or more or less lenticular. Vessel-parenchyma pits numerous, bordered, rounded to elliptical, apertures circular.

Fibres libriform. Medium, 1100–1350 μ in length, 14 μ in diameter. Arranged uniformly in radial seriations, squarish to polygonal as seen in cross-section. Aseptate. Pits to fibres simple, small, circular.

Parenchyma in limited amount. Paratracheal and apotracheal. Paratracheal mostly in 1–3 cells thick vasicentric to aliform sheaths; sheaths never become confluent. Apotracheal parenchyma consists of (1) 1–3 cells thick initial bands placed in between the growth rings, and (2) diffuse cells or groups of cells, 1–4 in number. Parenchyma cells round to oval, 20–30 μ in diameter, mostly empty. Pits numerous, simple, circular.

Xylem rays numerous, 15–30 per mm. Evenly distributed. Almost exclusively uniseriate, 2–20 cells high. Generally homogeneous, rarely weakly heterogeneous with a single marginal row of vertical cells. Generally a single crystal fills up the individual ray cells.

Holotype.—No. 4976. The type specimen and the slides are kept in the museum of Birbal Sahni Institute of Palæobotany, Lucknow.

Locality.—Mortandra.

Summary

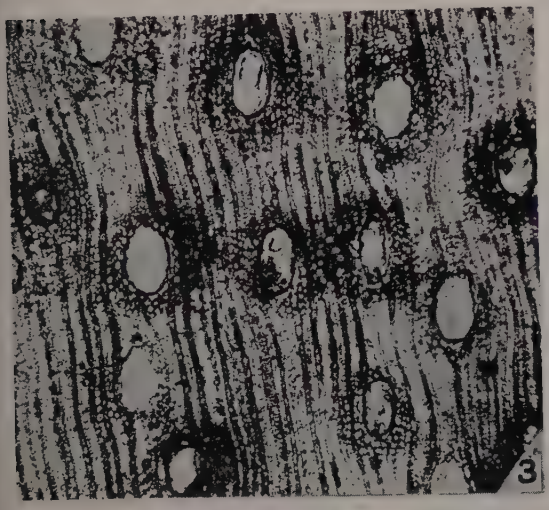
Two new species of fossil woods resembling the modern genus *Terminalia* have been described for the first time from India, from the Tertiary rocks of South Arcot District, Madras.

Terminalioxylon speciosum is characterised by uniformly distributed, solitary, usually tylosed vessels, fairly large, vestured and alternate intervessel pits, aseptate libriform fibres, vasicentric to aliform often locally confluent abundant paratracheal parenchyma and diffuse apotracheal parenchyma, and 1–2 seriate weakly heterogeneous xylem rays with cells containing single crystals.

Terminalioxylon Felixi contains indistinct growth rings, solitary or radial groups of 2–3 evenly distributed vessels, fairly large, distinctly vestured and alternate intervessel pits, aseptate, libriform fibres, limited parenchyma in narrow vasicentric to aliform sheaths, and initial bands between the faint growth rings, and lastly almost exclusively uniseriate, generally homogeneous xylem rays with crystalliferous cells.

Acknowledgements

The author is highly indebted and grateful to Dr. R. V. Sitholey, for his valuable guidance, and critical perusal of the manuscript.



C. G. K. Ramanujam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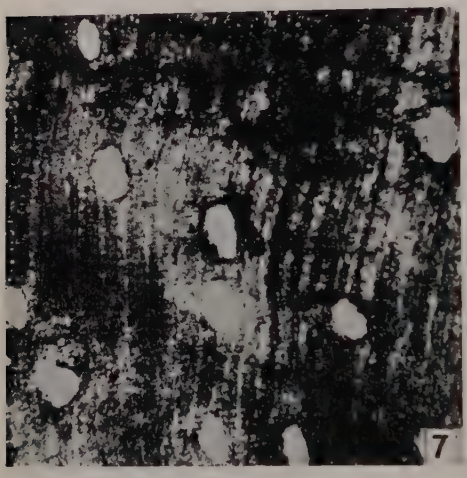
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Explanation of the Plates

(All the photomicrographs are from untouched negatives)

Plate VI

Fig. 1. A general view of the fossiliferous locality near Mortandra.

Figs. 2–5, *Terminalioxylon speciosum* sp. nov.

Fig. 2. Intervessel pitting, ×200.

Fig. 3. Cross-section showing the distribution of the parenchyma, ×50.

Fig. 4. Cross-section showing the vasicentric and diffuse parenchyma, ×50.

Fig. 5. Tangential section to show the general nature of the xylem rays, ×50.

Plate VII

Fig. 6. *Terminalioxylon speciosum* sp. nov.

Fig. 6. Radial section showing the weakly heterogeneous rays, ×50.

Figs. 7–11. *Terminalioxylon Felixi* sp. nov.

Fig. 7. Cross-section showing the initial bands of the apotracheal parenchyma, ×50.

Fig. 8. Cross-section showing the vasicentric to aliform parenchyma, ×50.

Fig. 9. Tangential section to show the general nature of the xylem rays. Note the tyloses in the vessels, ×50.

Fig. 10. Tangential section slightly enlarged to show the crystalliferous cells in the xylem rays (*c*), ×50.

Fig. 11. Radial section to show the homogeneous nature of the rays, ×50.

SAPUCCHAKA, A NEW GENUS OF THE HEMISPHAERIALES

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(Received for publication on November 30, 1955)

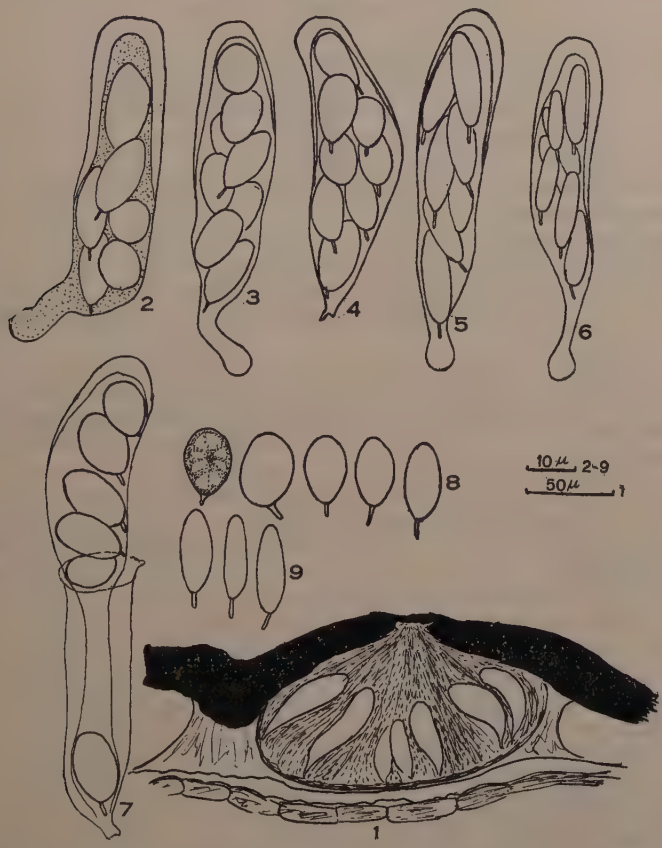
The fungus which forms the subject of this paper was found growing on dead twigs of *Quisqualis indica* Linn., at the University Botany Laboratory campus, Madras. A description of the fungus is given below.

The fungus forms black, somewhat circular or oval ascomata on the surface of the twig. The ascomata are entirely superficial without any free mycelium. The ascomata which measure ½–1 mm. in diameter may coalesce and form irregular patches. There is a clear ostiole-like opening at the centre which is slightly bulged out. The shield is made up of dark brown pseudoparenchymatous cells except at the margins where these cells are arranged radially. A cross-section shows that the ascomata are thyriothecia, each such thyriothecium enclosing a single locule and a single hymenium. The hymenium is made up of asci and paraphyses-like interthecial threads. The asci and the interthecial threads arise from a layer of thin-walled, subhyaline cells which form the lower wall of the thyriothecium. The asci are stout, broadly club-shaped, with a rounded or flattened apex and a narrow foot at the base. They measure $70–93 \times 15–22\,\mu$. The ascus is bitunicate with a thick inner and a thin outer wall. The ascospores form the most characteristic and interesting feature of the fungus. These are 8 in each ascus and are arranged in two irregular rows. They are hyaline, one-celled and ovoid in shape and measure $16–21 \times 8–13\,\mu$. Each ascospore is provided with a short, basal appendage which is hyaline and of uniform thickness or tapering from a slightly broadened base. This appendage seems to be made of the same material as the ascospore wall. The appendage is not mucoid and is not dissolved by lactic acid when mounted in this medium.

In addition to these ovoid ascospores certain other narrower and elongated, fusiform ascospores were also found in the material. These spores were also provided with the basal appendage. An ascus either contained the ovoid ascospores exclusively or the elongated ascospores; the two were not found mixed together in the same ascus. It is not clear whether the elongated ascospores were degenerate ones. Their protoplasm did not show any signs of disintegration.

The structure of the ascomata clearly shows that the fungus belongs to the Microthyriaceæ of the Hemisphæriales. The only genus of the Microthyriaceæ with caudate ascospores is *Caudella* Sydow (Stevens and Ryan, 1939). In this fungus, however, the ascospores are two-celled and the ascomata are aparaphysate. There is free mycelium present. The present fungus, therefore, has to be accommodated in a

new genus. It is named *Sapucchaka* (from the Sanskrit, *Pucchaka* = a short tail).



FIGS. 1–9. *Sapucchaka madreeya.* Fig. 1. Section of a thyriothecium (diagrammatic). Figs. 2–4. Asci containing ovoid ascospores. Figs. 5–6. Asci containing narrow ascospores. Fig. 7. A dehisced ascus. Fig. 8. Ovoid ascospores. Fig. 9. Narrow ascospores.

Sapucchaka gen. nov.

Pertinent ad Ascomycetas. Hemisphæriales, Microthyriaceæ.

Mycelio nullo; ascomata superficialia, dimidiata, nigra, circularia; scutum radiale ad margines, ornatum foramine ostioli simili in centre; loculus unus in unoquoque ascomate, includens hymenium unicum, quod constant ex ascis atque filamentis paraphysis similibus; asci bitunicati; ascosporæ octo in singulis ascis, semel cellulatæ, hyalinæ, singulæ, ornatæ appendice brevi basali caude simili.

Sapucchaka madreeya sp. nov.

Mycelio nullo; ascomata superficialia, dimidiata, nigra, circularia vel irregularia per coalescentiam, 0·5–1 mm. diameter, ornata foramin-

claro in centro ostioli simili; scutum constans ex cellulis fusce brunneis, pseudoparenchymaticis, quae ad margines radialiter sunt dispositæ; hymenium ornatum unico vallo ascorum surgenti e serie basali ascomatis; series basalis constans e minutis cellulis subhyalinis; asci robusti, late clavati, bitunicati, rotundati vel complanati ad apicem superiorum, breviter pediculati ad basim, 70–93 × 15–22 μ; ascosporae irregulariter distichæ, hyalinæ, semel cellulatæ, ovoideæ, 16–21 × 8–13 μ; singulæ ascosporæ ornatæ brevi appendice recta caude simili; appendix uniformiter crassa per totam longitudinem, vel crassior ad basim, fastigiata ad apices, 4·8 × 1·6 μ; paraphyses angustæ, filiformes, inter ascos dispositæ.

Typus lectus in ramis emortuis *Quisqualis indicæ* Linn., in campo laboratorii botanici universitatis, in urbe Madras, die 4 mensis novembris, anni 1955 a K. Ramakrishnan, et positus in herbario M.U.B.L. sub-numero 1414.

I thank Prof. T. S. Sadasivan for much encouragement, the Rev. Fr. Dr. H. Santapau, S.J., for kindly translating the diagnoses into Latin and Prof. V. Raghavan for suggesting the Sanskrit name of the fungus.

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NATURAL REGENERATION IN *POGONATUM* PALIS

By R. S. Chopra and P. D. Sharma

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(Received for publication on July 18, 1955)

While collecting materials for the study of the life-history of *Pogonatum* Palis, one of the Polytrichaceæ, certain young specimens of *P. perichætiale* (Mont.) Jæg. growing on the leaves of the same species were seen. On further examination it was found to be a common feature. It was thought to be of interest to study the growth of plants from the leaves and to know which part of the leaf gives rise to plants.

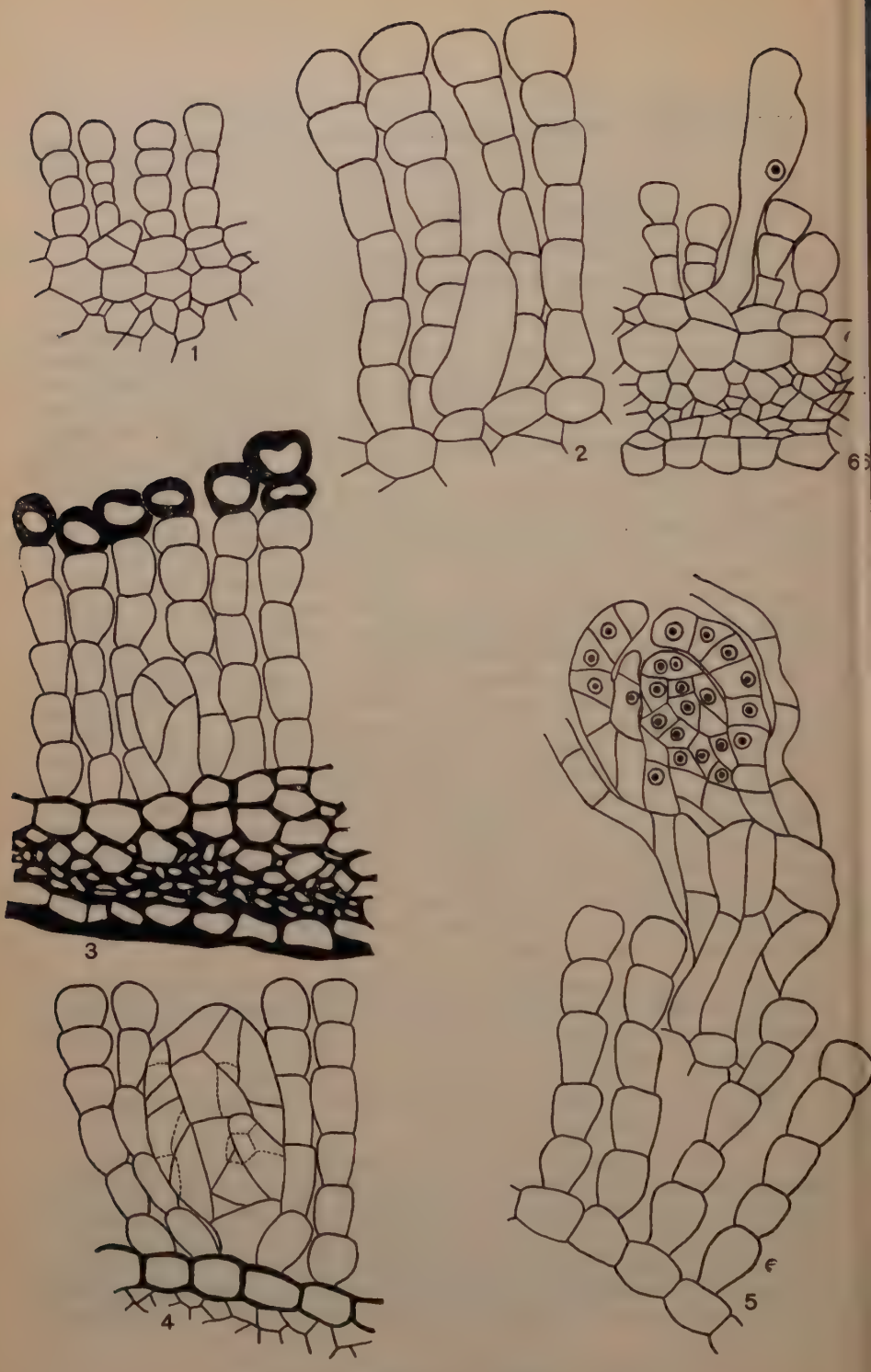
The material was collected from Depot Road, Mussoorie (Western Himalayas) and was fixed in Formalin-acetic-alcohol. Sections were cut from 8–10 μ thick and stained with Safranin and Fast green.

On most of the leaves only a single mature plant is seen but the leaves with more than one plant, *i.e.*, two, three or even four are also quite common. On a single leaf several plant initials, *i.e.*, buds are formed to start with but in most cases only one plant grows to maturity. The cells of the upper surface of the leaf, *i.e.*, cells which produce and bear lamellæ on them, assume meristematic activity. A cell enlarges and cuts off another cell which lies in the space between the two adjacent lamellæ (Fig. 1). This cell in turn enlarges considerably (Fig. 2) and divides by three oblique walls to cut off an apical cell (Fig. 3). The apical cell is developed by the first few divisions, so that the plant has got direct union with the surface of the leaf and no protonema in the usual sense of the term is developed. The apical cell cuts off segments and further development takes place to form a mature plant (Figs. 4 and 5). The origin of the leaf from the segments of the apical cell is not clear even in very young plants growing on leaves due to the condensed growth at the apex.

Sometimes the enlarging cell formed by the first division extends above, becomes linear and projects above the lamellæ (Fig. 6). This extending cell may even branch sometimes but it has never been observed to produce a young plant.

Regeneration from the lower portion of the stem has also been observed in a specimen.

It is not possible to say which portion of the leaf regenerates more effectively as studied by other authors in some other mosses in cultures because the present study has been made from naturally occurring regeneration. In this case an extensive protonema as described by Kachroo (1954) in *Physcomitrium pyriforme* Brid. and by Meyer (1942–43) in *Physcomitrium turbinatum* (Michx.) Brid. (in both cases in cultures) does not develop and when it does develop to a certain extent it does



FIGS. 1–6. *Pogonatum perichætiale*, ×500.

not produce a new plant. In this study it is seen that the cell which has to give rise to the plant divides immediately so that that plant has got direct union with the surface of the leaf as described by Gemmal (1953) in *Atrichum undulatum* (Hedw.) P. Beauv. This gives a better fixation and the growing plant may be drawing food from the leaf upon which it grows.

Our thanks are due to Prof. P. N. Mehra for going through the manuscript and making some useful suggestions.

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PROBABLE FACTORS RESPONSIBLE FOR FORMATION OF SPOROGONIA IN *MANNIA INDICA* ST. AND *ASTERELLA PATHANKOTENSIS* KASH.

By P. Kachroo

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(Received for publication on September 12, 1955)

Among bryophytes studies on physiology have been mainly confined to mosses. Garjeane (1932) in a paper on Physiology (*cf.* Verdoorn, 1932) reviews the literature on the subject from 1900 onwards. 'Vakblad voor Biologen' 1920, Nr. 4 lists biologic literature from 1903–20. Servetaz (1922) first made a pure culture of mosses and the importance of such cultures was stressed upon by Pringsheim (1924).

The present communication is a preliminary note on the factors influencing the formation of female receptacle and sporogonia on the ventral shoots of *Mannia indica* and *Asterella pathankotensis*. The species were collected *en masse* with adherent soil (pH 8·5) from Pathankot and Hoshiarpur (Punjab) during February-March, 1950 and later cultivated as such in wooden boxes on canal soil (pH 7·0 approximately) in the Panjab University Botany Laboratory at Amritsar.

The experiments were performed on 225 plants. Sterilised canal soil in Petri dishes was employed for cultures which were kept at room temperature.

Experimental

(*a*) The apical portions of the thalli were cut and grown separately. The remaining portion of the thallus was allowed to grow; some male receptacle-bearing parts were segmented in such a way as to have two portions—one with male receptacle and the other without it.

(*b*) The ventral shoots were removed from the thalli and grown separately. These were removed at different stages of development as follows:—

(i) Very young ventral shoots with no indication of female receptacle.

(ii) Young ventral shoots showing the initiation of female receptacle.

(iii) Young ventral shoots with visible receptacle.

In the above experiments the apical portions of the vegetative thalli continued growth primarily due to the presence of apical cell. From the longitudinally segmented equal portions of the apical segment each showed capacity for shoot formation. Even two shoots were formed

from the same region but it could not be determined whether one or more cells were involved in their formation. The fragmented male-less portions rarely formed lateral shoots.

The male cushion-bearing fragments did not form vegetative shoots from their basal regions.

The ventral shoots already developing with the unsegmented male fragments behaved normally with regard to sporogonia formation; where the female receptacles were evident the sporogonia were formed in the normal manner, when these were just dot-like in appearance the sporogonia formation was rare or absent.

The growth of the stalk of the female receptacle appeared to be related to the development of the sporogonia, since when the sporogonia attain maturity there is no increase in the length of the stalk.

In the very young ventral shoots where probably the receptacle development had not started, fruiting was absent and vegetative shoots were formed instead.

The parent thalli without the male cushion continued to live and formed vegetative shoots. In no case did these produce fresh sexual shoots. On dissecting them along the mid-rib vegetative shoots were only produced along their margins and even from the notch of the ventral shoots, but never from the midrib region.

The extent of fruiting by the fragmented portions is shown below:—

	Portion used	Frequency of fruiting			Total No. of plants or fragments
		Frequency %	Rare %	Very rare %	
1	Apex with male receptacle	98	..	..	160 fragments
2	Ventral shoots with just visible female receptacle	..	30–40	5	160 shoots
3	Ventral shoots with visible female receptacle	90	..	5 due to injury	150 „
4	Ventral shoots without formation of female receptacle	..	..	..	200 „
5	Ordinary vegetative shoots	100	..	..	75 „
6	Same under continued humid conditions	..	..	12	75 „

It will be seen from the above that: frequency of fruiting was maximum in the ordinary vegetative shoots and less so in the segmented male cushions and ventral shoots with visible female receptacles. It was

minimum in ventral shoots with the initiation of female receptacles and very rare in the vegetative shoots growing under extreme moist conditions.

The growth of the plants as observed under cultural conditions is of the following order:—

(i) the vegetative shoots show indefinite growth under humid conditions;

(ii) the stalked female receptacles on the detached ventral shoots form sporogonia earlier (*economy of time*);

(iii) the vegetative shoots formed by the fragments bearing male cushion show comparatively slower growth; and

(iv) the very young ventral shoots show little or no growth.

Conclusions

The midrib of the parent thallus is continuous with the midrib of the ventral shoots; the stalk of the female receptacle is actually terminating the midrib of the ventral shoots; the antheridial cushion is also in direct contact with the midrib; on removing the male cushion-bearing region of the thallus the female receptacle on the ventral shoots, hitherto small or absent, do not form sporogonia but vegetative shoots instead; the already developing female receptacles behave normally and form sporogonia and spores *comparatively* earlier than the controls and in cases where the receptacles are in their primordial stages the frequency of fruiting is rare.

It thus appears that the male cushion controls in some way the fruiting of the species. It is possible that it acts as a stimulus in initiating the sexual development in the notch of ventral shoot and the midrib conveys this stimulus. The fact that the ventral shoots removed from the decapitated thallus do not form female receptacles (even though near the male-cushion fragments and normal thalli) supports the probable influence of the presence of the male cushions on the initiation of the female receptacles.

The formation of the vegetative shoots from the margin is due to wound stimulus.

I am grateful to Prof. P. N. Mehra for laboratory facilities and for his interest in me and my work, to Prof. A. C. Joshi for encouragement.

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SOME ABNORMAL CONES OF *EQUISETUM DEBILE* ROXB.

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(Received for publication on November 2, 1955)

Milde (1865) in his monograph on *Equisetum* described some proliferated cones of *Equisetum maximum* and gave them a verietal status. Later on Ridley (1884) did not approve of this status being given to these monstrosities which according to him were due probably to accidental circumstances. Subsequently Bower (1904), Goebel (1918), Allen (1928), Kashyap (1930) and Tschudy (1939) also described such abnormalities in various species of the genus. Kashyap (1930) described three specimens of *Equisetum debile* each having two cones separated by two sterile leaf-sheaths and claimed such a condition to be unknown in any other species of the genus.

In November 1954 during a visit to a stand of *Equisetum debile* on the banks of Kali Nadi near Saini village, about eight miles from Meerut, I also came across some abnormal specimens. They differ from Kashyap's specimens in their gross structure and the structure of their components. One of the specimens was found to have the cone divided into two segments by a narrow transverse constriction having a fertile sheath comparable to an annulus, another specimen showed a short proliferated shoot, and a third one with a long proliferated shoot above the cone.

It may be worthwhile to describe these specimens in some detail.

In the first specimen the lower fertile portion is somewhat abnormal in this respect that its annulus is fertile and bears some sporangia on it, a condition reported in some normal cones of certain species (*cf.* Smith, 1938). Above the annulus there are four whorls of sporangiophores* of which the lower three have 'discs' laterally compressed and the fourth has 'discs' which are somewhat rounded or oval. From the centre of each 'disc' of fourth or the last whorl there comes out a small spiny projection (Fig. 1). In this whorl each 'disc' has only two sporangia and is attached to a flattened horizontal stalk by its lower margin (Figs. 1–3). After a narrow constriction there follows the upper portion of the cone having a distinct fertile annulus similar to that of the lower portion. In this portion the 'discs' are not hexagonal but somewhat circular with lobed margins. They become smaller towards the top of the cone. The sterile leaf-sheath below the annulus of the cone has nine acuminate teeth (Fig. 1).

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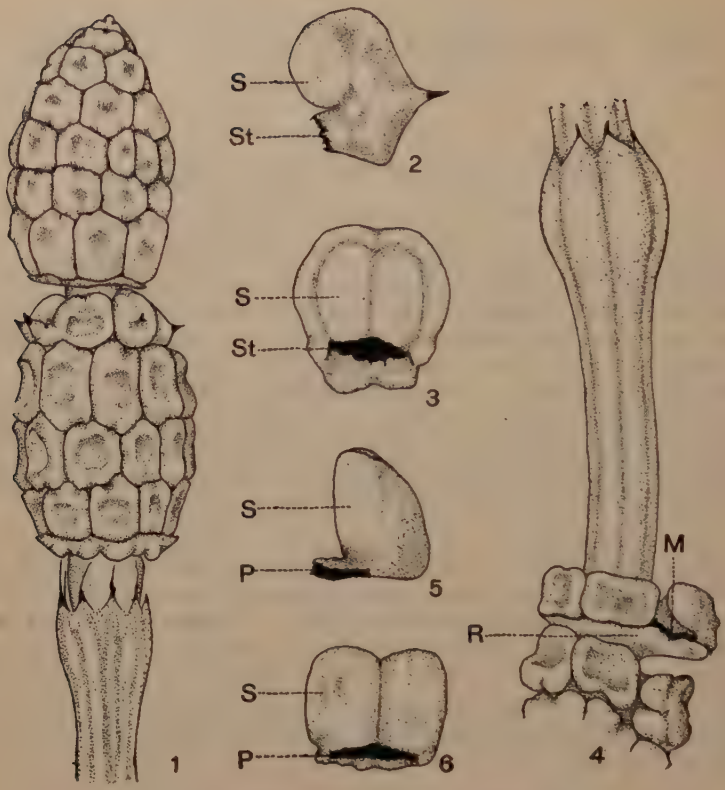
* Tschudy (1939) has discovered some correlation between the leafy character of the sporangiophore and the number of sporangia, and as a result of this he arrives at the conclusion that the sporangiophore should better be regarded as a sporophyll than anything else.



FIGS. 1–6. *Equisetum debile*. Fig. 1. Abnormal cone with a median constriction. Figs. 2–3. Sporangiophore of the fourth whorl of the same in lateral and adaxial views respectively. Fig. 4. Upper part of the cone with long proliferation showing the 'discs' attached to the margin of the 'rim'. Figs. 5–6. Sporangiophore of the last whorl of the same in lateral and adaxial views respectively. *M*, margin of the 'rim' from where the 'disc' has been removed; *P*, place of attachment of the 'disc' to the 'rim'; *R*, 'rim'; *S*, sporangia; *St*, stalk of the sporangiophore.

In the second case the cone has a small proliferation at its top. The annulus is fertile as in the first specimen, and above it there are three whorls of sporangiospores. Whereas the lower two whorls are normal with hexagonal 'discs', the third whorl has 'discs' that are somewhat laterally compressed. The sterile leaf-sheath below the annulus is nine-toothed with acuminate ends. Above the cone is a small shoot with three small internodes and nodes bearing normal sterile leaf-sheaths each having seven unequal teeth.

In the third case the stalk of the cone is very delicate as compared to stalk of normal cones, the annulus is fertile with distinct sporangia on the upper surface. There are only two whorls of sporangiophores, lower whorl with 'discs' somewhat square in shape, and upper one

having laterally elongated 'discs'. The 'discs' of the second or the last whorl are peculiar in having no slender stalk but their lower margins are fused all along their length to the margin of a 'rim' (Figs. 4–6). The sterile sheaths below the cone have got six teeth with acuminate ends (except the sterile sheath just below the annulus of the cone which has bluntly pointed teeth and forms a saucer-shaped structure). A proliferated shoot is also present above the cone with three long internodes and normal sterile leaf-sheaths each with six bluntly pointed teeth.

Grateful thanks are due to my respected teacher Dr. V. Puri, for guidance and encouragement. I am also thankful to Mr. Y. S. Murty, for valuable help.

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EMBRYOLOGY OF THE PASSIFLORACEÆ

I. Gametogenesis and Seed Development of *Passiflora calcarata* Mast.

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Received for publication on November 2, 1955

The Passifloraceæ included by Engler and Prantl (1925) in the order Parietales comprise eleven genera of which the genus *Passiflora* has 400 species most of them being distributed in the tropics and a few in sub-tropical Asia. Gamble (1919) reports one species of *Passiflora* and two of *Adenia* in South India. Recently, Chakravarty (1949) has made a review of the Indian Passifloraceæ. He has reported 25 species of *Passiflora* and seven of *Adenia*. *Passiflora calcarata* Mast. is an introduced plant now growing wild in many parts of South India.

Previous work on the embryology of the Passifloraceæ is meagre. Schnarf (1929, 1931) has reviewed the embryological features of this family. Some observation on the peculiar behaviour of the pollen tube in *Passiflora adenophylla* has been made by Cook (1909). In a comprehensive survey of seed-coat structure of angiosperms, Netolitzky (1926) has referred to the seed-coat and aril of *Adenia venenata*, *Passiflora holoserecea* and *P. hirsuta*. The present investigation deals with the development of gametophytes and seed of *Passiflora calcarata* Mast.

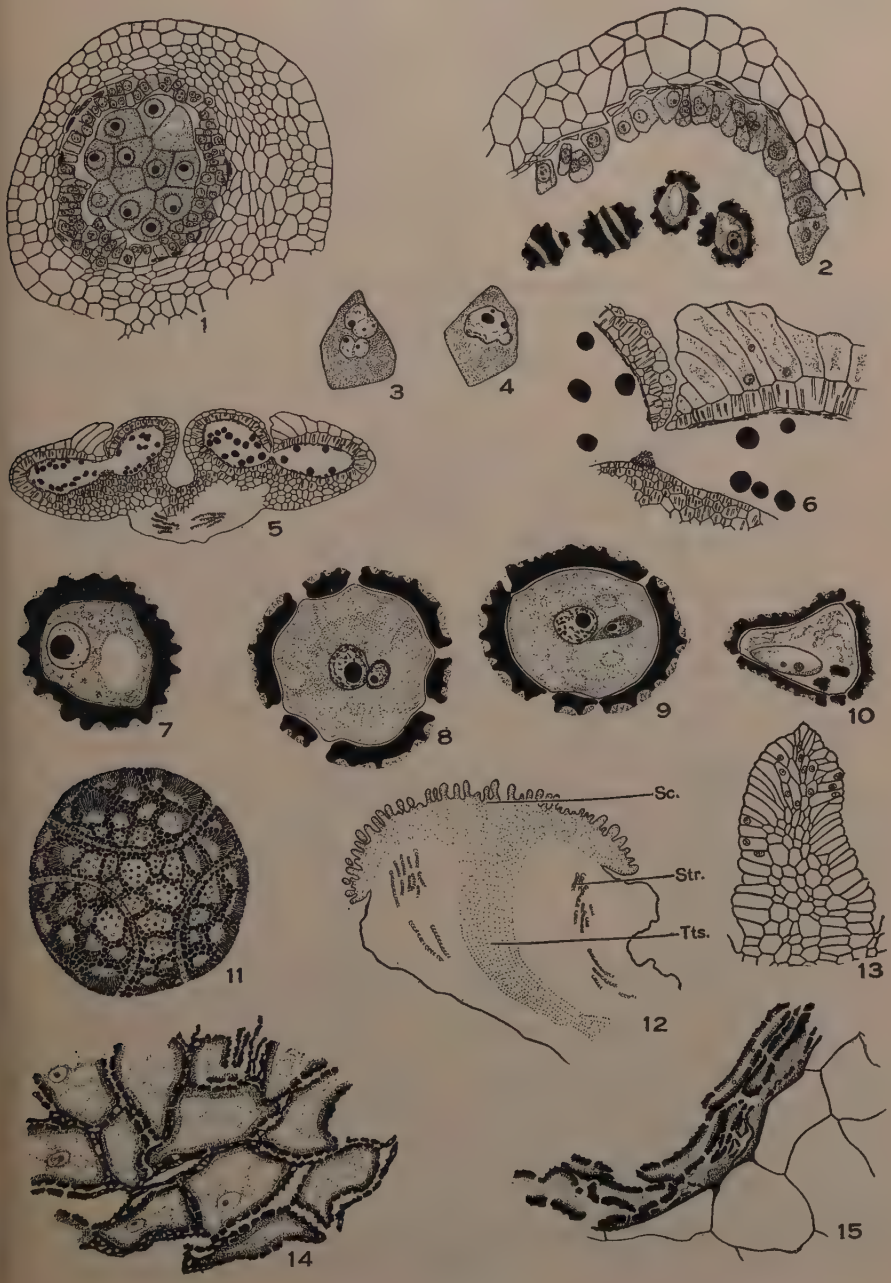
Abbreviations

A, aril; *Ce*, cellular endosperm; *Cot*, cotyledon; *Cs*, chalazal vascular strand; *Ct*, chalazal tissue; *Emb*, embryo; *Fs*, funicular strand; *Fu*, funiculus; *Ii*, inner integument; *In*, ingrowths; *N*, nucellus; *Ne*, nuclear endosperm; *Oi*, outer integument; *Ppt*, persistent pollen tube; *Sc*, stigmatic crest; *Str*, stylar tracheids; *Tts*, transmitting tissue.

Observations

Microsporangium and male gametophyte.—The microsporangium in transverse section has a group of microspore mother cells surrounded by a glandular tapetum (Fig. 1). The anther wall comprises the epidermis, endothecium, two to three middle layers and the tapetum (Figs. 1, 2). In later stages, the middle layers get crushed and the endothecium develops fibrous thickenings (Figs. 5, 6). Such thickenings are also seen in some cells of the connective (Fig. 5). The epidermal cells of the outer loculi get very much enlarged near the region of dehiscence (Figs. 5, 6). The tapetal cells are glandular, binucleate and biseriate at certain regions (Fig. 1). Their nuclei often show tendencies of repeated fusion (Figs. 3, 4). At the shedding stage the pollen grains

are two celled (Figs. 8, 9). They show heavy reticulate thickenings (Figs. 7–11).



FIGS. 1–15

FIGS. 1-15. Fig. 1. Transverse section of a young anther lobe showing spore mother cells, tapetum and the wall, ×50. Fig. 2. A portion of anther at a later stage with epidermis, wall layers, tapetum and microspores, ×50. Fig. 3. Tapetal cell with free nuclei, ×216. Fig. 4. Same with a single nucleus formed by the fusion of free nuclei, ×216. Fig. 5. T.s. of anther at the time of dehiscence, note the fibrous thickenings and also the enlarged epidermal cells at the region of dehiscence. ×6. Fig. 6. Same at the region of dehiscence enlarged, ×13. Fig. 7. Section of uninucleate microspore, ×216. Fig. 8. Section of two-celled microspore showing six germinal areas, ×216. Fig. 9. Same at a later stage, ×216. Fig. 10. Section of distorted pollen grain with a hypertrophied nucleus and two darkly stained bodies, ×216. Fig. 11. Surface view of the entire pollen grain showing reticulate sculpturing of exine, ×216. Fig. 12. Longi-section of tip of the style showing stigmatic crest with multicellular outgrowths, ×6. Fig. 13. A multicellular outgrowth. ×50. Fig. 14. Abnormal distorted pollen grains in the anther locule, ×100. Fig. 15. Same, grains pushed to a side of the anther locule. ×100.

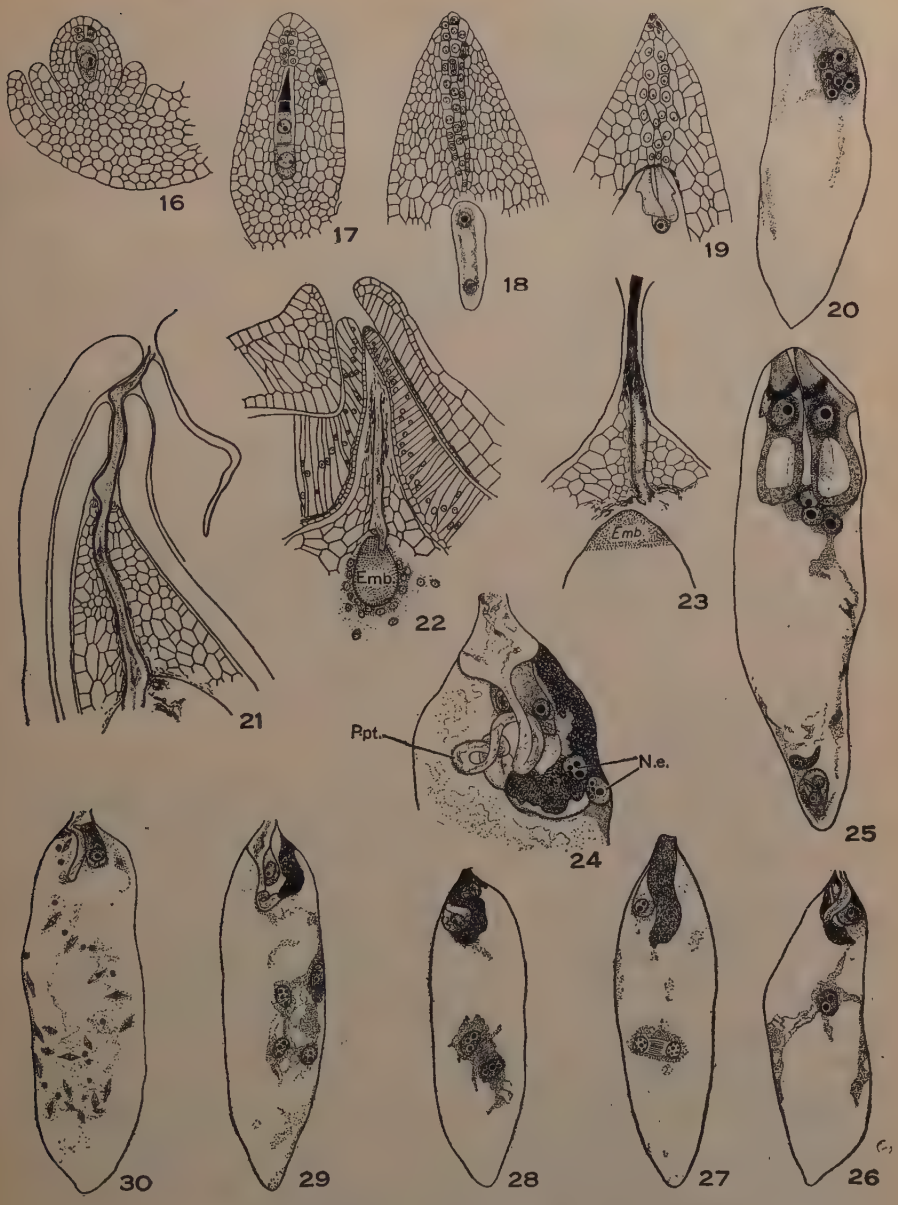
Several cases of degeneration of pollen grains are noticed. They present a distorted appearance (Fig. 14) and are pushed towards the wall of the anther (Fig. 15). Such pollen grains become prominently vacuolate and have hypertrophied nuclei which stain very lightly (Figs. 13–15).

Megasporangium and female gametophyte.—The ovules are crassinucellate, bitegmic and are borne on parietal placentæ. A few ovules in the locule of the ovary remain orthotropous. The ovular primordia develop from the placenta as small projections. The integumental initials are laid down at the time of archesporial differentiation. Soon they develop further and the ovules take an anatropous bend. The micropyle is organised by the two integuments (Fig. 21). The nucellar cells divide actively till the two-nucleate stage of the female gametophyte (Figs. 16–19). Some of them at the micropylar end are elongated and contain dense cytoplasm. During post-fertilization stages, the nucellus becomes irregular in outline due to the development of ingrowths from the seed-coat (Fig. 43).

At the tetrad stage of megaspores, the nucellar cells at the chalazal region of the ovule become conspicuously stained. During seed development this becomes differentiated into the chalazal tissue into which the vascular strand branches freely. A few cells of this region in contact with the lower end of the endosperm become slightly elongated (Figs. 31–38, 43, 43 *e*).

The archesporium is hypodermal and it divides transversely forming the upper primary parietal cell and the lower megaspore mother cell. The parietal cell by further divisions forms the parietal tissue. The megaspore mother cell undergoes meiosis and a linear tetrad of megaspores is formed (Fig. 17), of which the upper three degenerate and the lowermost develops into the embryo sac (Figs. 18, 25) of the Polygonum type (Maheshwari, 1948). The synergids are hooked and show filiform apparatus. The egg is situated between and often below them. The ephemeral antipodal cells are situated at the attenuated chalazal end of the embryo sac.

Many instances of degeneration of megaspore tetrads and embryo sacs are observed and the former appear as dark deeply stained masses.



FIGS. 16–30. Fig. 16. L.s. of ovule showing the integuments, parietal cells and megaspore mother cell, ×50. Fig. 17. Nucellus showing a linear tetrad of megaspores of which the upper two have degenerated, ×50. Fig. 18. Same at a later stage showing a few layers of radially elongated nucellar cells and two-nucleate embryo sac, ×50. Fig. 19. Nucellus at the mature embryo sac stage, ×50.

Fig. 20. An abnormal embryo sac with aggregation of six free nuclei at the micropylar end, ×100. Fig. 21. L.s. of ovule at the region of micropyle showing the irregular micropyle and pollen tube, ×50. Fig. 22. Same at a later stage with scanty nucellus, persisting pollen tube and developing embryo, ×50. Fig. 23. Same at a still later stage, ×50. Fig. 24. A case showing convolutions of pollen tube, ×100. Fig. 25. Mature embryo sac, ×100. Fig. 26. Stage in double fertilization, ×50. Figs. 27–30. Stage in development of endosperm, ×50.

In an abnormal embryo sac six nuclei are seen aggregated at the micropylar end (Fig. 20).

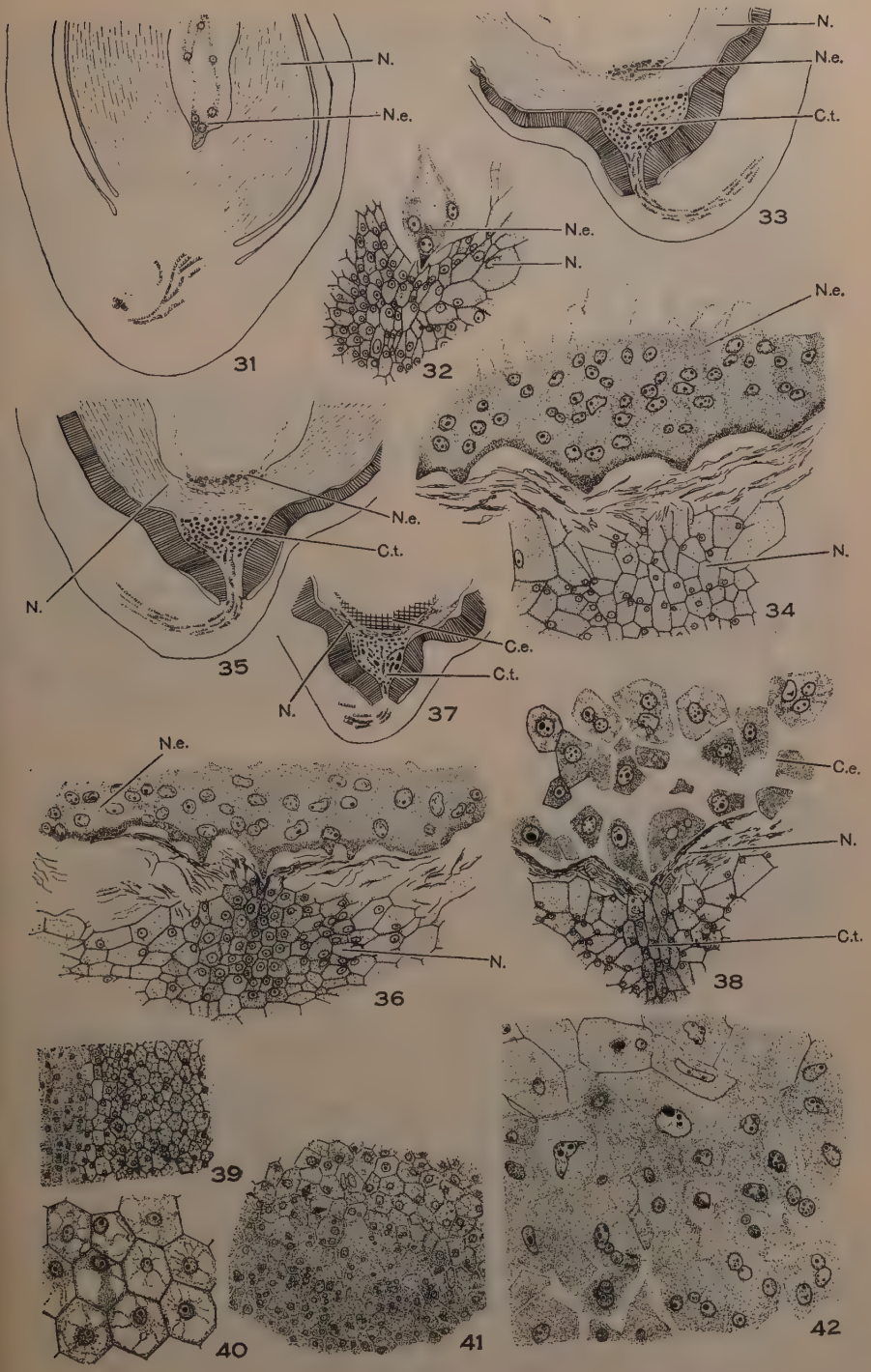
Stigma, Pollen tube and Fertilization.—The tricarpellary ovary has three stylar branches, each ending in a globose stigma. In a sectional view of the solid style, the transmitting tissue spreads over the stylar tip and develops conical outgrowths to form the receptive structure (Fig. 12). The former can be differentiated from the stylar tissue. The outgrowths of the stigmatic crest (Figs. 12, 13) facilitate in the retention of the pollen grains.

The pollen tube emerges out of one of the furrows in the equatorial region and penetrates into one of the multicellular outgrowths of the stigmatic crest. Then it reaches the ovarian cavity through the transmitting tissue of the style. The pollen tube is quite prominent and makes its entry through the irregular micropyle into the embryo sac, destroying on its way the radiating cell layers of the nucellus (Fig. 21). It has a thick wall and persists during later stages of seed development (Figs. 21–33). In some of them the presence of cytoplasm is quite evident (Figs. 21–24). Many cases of pollen tube convolutions have been observed near the micropylar end of the embryo sac (Fig. 24).

Double fertilization has been observed (Fig. 26). The pollen tube, as it enters into the embryo sac, destroys one of the synergids. It bursts open at the tip liberating darkly stained substances (Fig. 24) and the male nuclei, one of which fuses with the egg and the other with the secondary nucleus (Fig. 26).

Endosperm.—The primary endosperm nucleus by repeated divisions forms a large number of nuclei (Figs. 27–30). These aggregate in a dense mass of cytoplasm at the chalazal region (Figs. 34, 43). A similar accumulation of nuclei is also noticed around the developing embryo (Fig. 22). In early stages of endosperm development, the nuclei in chalazal portion become conspicuous. This portion of endosperm closely abuts on the nucellus between the chalazal tissue and the lower region of the embryo sac (Figs. 35, 36). Later, as development proceeds, it comes into direct contact with the chalazal tissue (Figs. 36, 38).

Cytokinesis around the free endosperm nuclei results in an endosperm tissue. It encroaches on the remaining nucellus and finally becomes irregular in outline (Fig. 51). The endosperm cells towards the periphery appear like meristematic cells and are deeply stained (Fig. 39). In the middle they are vacuolate and hexagonal (Figs. 39, 40). At the chalazal end they contain hypertrophied nuclei and are plurinucleate. In a few cells nuclear fusions are noticed (Figs. 41,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FIGS. 31–42

FIGS. 31–42. Fig. 31. L.s. of chalazal portion of a young seed showing massive nucellus and free nuclear endosperm with the cytoplasm penetrating into the adjacent nucellus, ×48. Fig. 32. Portion of the same at the chalazal region enlarged, ×109. Fig. 33. L.s. of chalazal portion of an older seed showing chalazal tissue and also a portion of nucellus digested by the nuclear endosperm, ×11. Fig. 34. Enlarged portion of the same, ×108. Fig. 35. L.s. of chalazal portion of a still older seed; ×11. Fig. 36. Same enlarged, ×108. Fig. 37. L.s. of a fairly mature seed showing cellular endosperm, degenerated nucellus and persistent chalazal tissue, ×7. Fig. 38. Same enlarged to show details, ×100. Fig. 39. Portion of endosperm in the middle region showing peripheral meristematic-like cells and hexagonal cells towards the centre, ×23. Fig. 40. Enlarged sketch of the central vacuolate hexagonal endosperm cells, ×67. Fig. 41. Chalazal portion of endosperm under low power showing nuclear activity, ×23. Fig. 42. Portion of same enlarged to show hypertrophied nuclei and various stages of nuclear fusion, ×67.

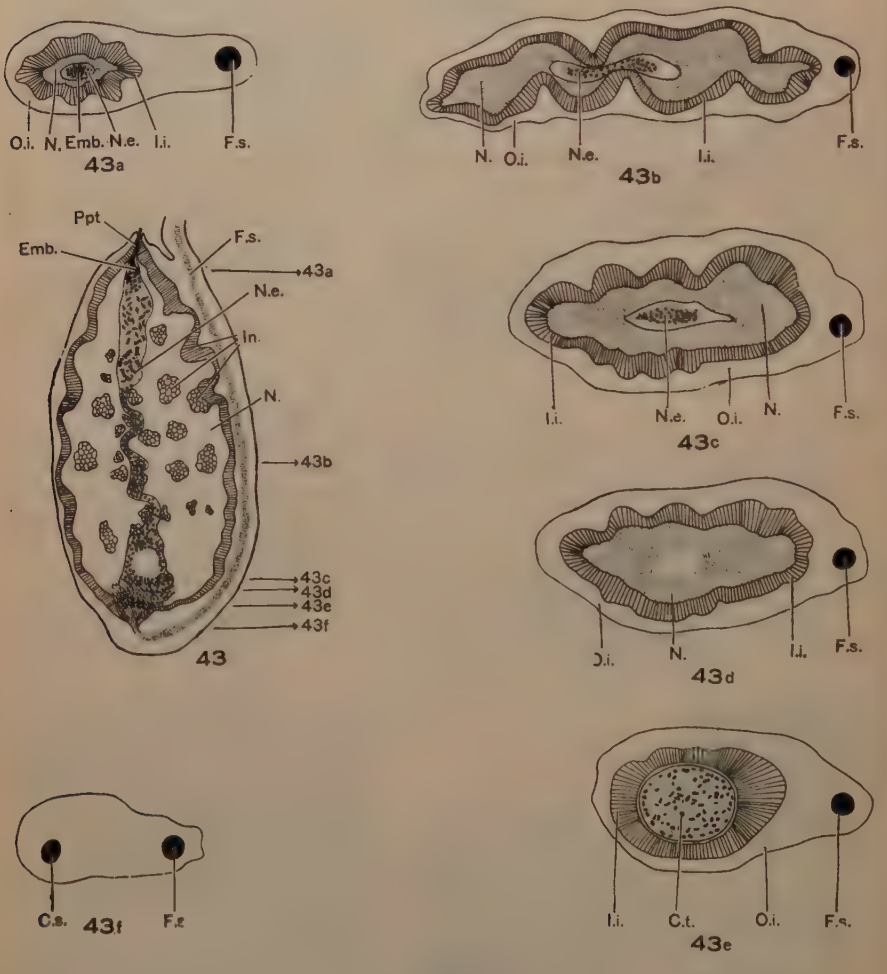
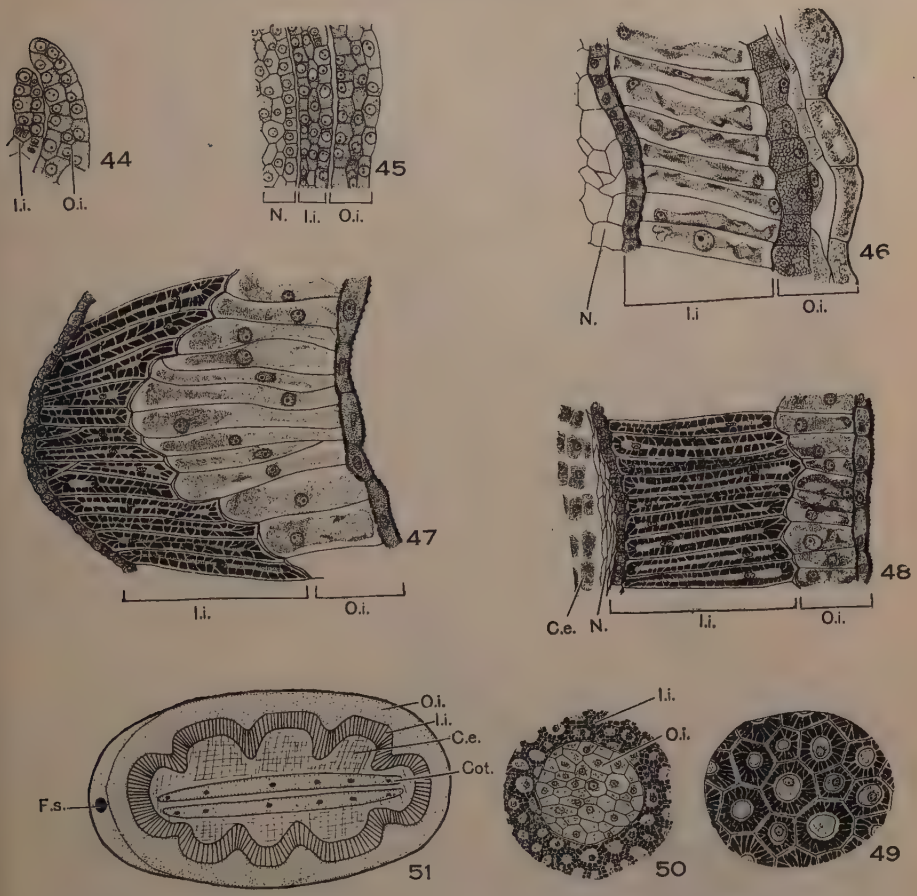


FIG. 43

FIG. 43. L.s. of a fairly old seed showing irregular embryo sac with free endosperm nuclei; note also the integumental ingrowths, ×6. Figs. 43 *a–f*. Transverse sections of the seed at different levels as indicated in Fig. 43, ×9.

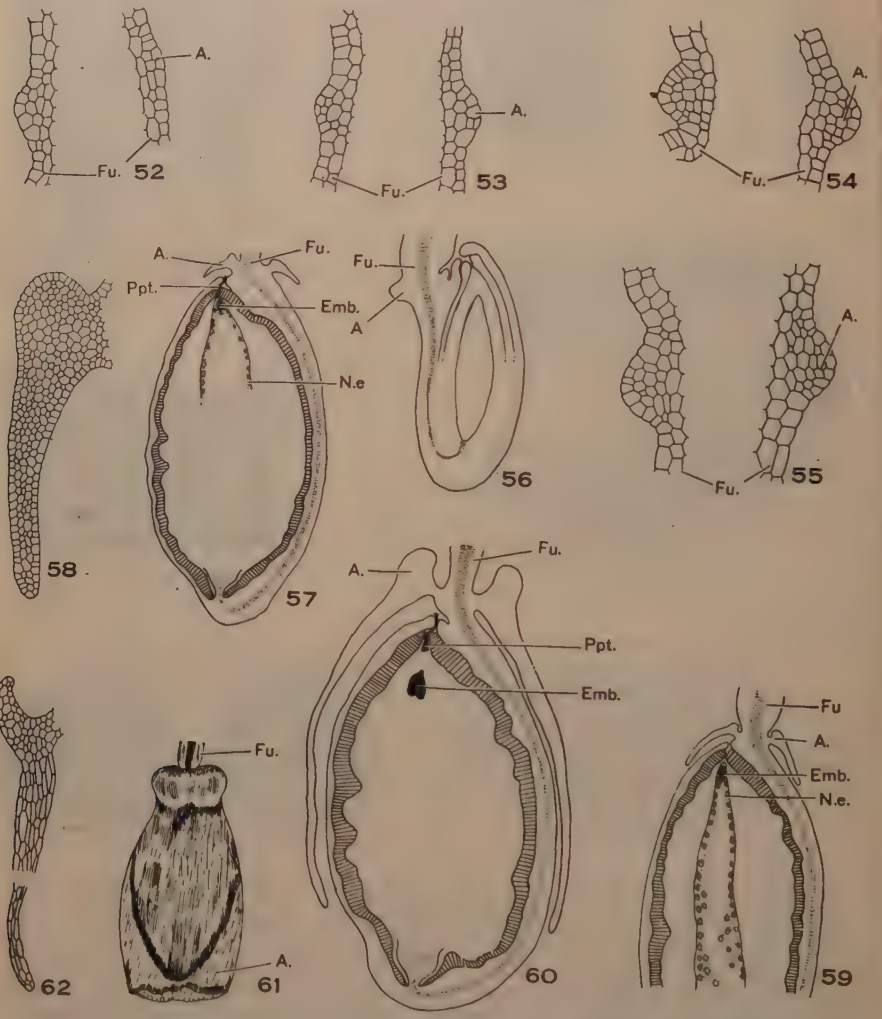


FIGS. 44–51. Fig. 44. L.s. of inner and outer integuments, ×67. Fig. 45. Later stage showing three layered inner and outer integuments, ×67. Fig. 46. Section of the seed-coat with disintegrating middle layer in each of the two integuments, ×40. Fig. 47. Section of the well-developed seed-coat at the region of the ingrowth, ×40. Fig. 48. Section of the seed-coat, ×40. Fig. 49. T.s. of lignified region of the integument to show simple and ramified pits, ×67. Fig. 50. T.s. of ingrowth showing the central outer integument surrounded by the sclerotic cells, ×33. Fig. 51. Diagrammatic transverse section of the mature seed showing ingrowths, cellular endosperm and cotyledons of the embryo.

42). During later stages of seed development the growing embryo consumes a portion of the surrounding endosperm.

Seed-coat.—The seed-coat is organised by the two integuments. The inner integument to start with is two layered and later by the

periclinal division of the inner layer becomes three layered (Figs. 44, 45). The outer integument is also three layered (Fig. 45). The middle layers of both the integuments get crushed during seed-coat organisation (Figs. 46, 48). In the mature seed the outermost layer of the



FIGS. 52–62. Figs. 52–60. Stages showing development of aril. Fig. 61. Diagrammatic sketch of the seed with the enveloped aril. Fig. 62. L.s. of a portion of the aril showing multilayered base and two to four layered tip. Figs. 52–55, ×44. Fig. 56, ×13. Fig. 57, ×3. Fig. 58, ×23. Figs. 59–60, ×3. Fig. 62, ×6.

outer integument has its outer wall echinulately thickened (Figs. 47, 48). The innermost layer consists of radially stretched cells (Figs. 47, 48).

The outermost layer of the inner integument becomes prominently elongated and lignified with both simple and ramiform pits (Figs. 47–49). The cells of the innermost layer are brownish and deeply stained (Figs. 47, 48).

The seed-coat develops ingrowths all round its inner surface (Figs. 43, 51). The inner integument is pushed in by the radial elongation of the cells of the innermost layer of the outer integument (Figs. 47, 50). The degree of radial elongation of the cells is not uniform throughout. So, this results in a wavy appearance on the inner surface of the seed-coat. These ingrowths which appear like ruminations do not extend deep into the seed.

Aril.—The seeds are arillate (Fig. 61). At about the tetrad stage of megaspores, the initials of the aril arise on the funiculus, just above the micropylar region of the anatropous ovule (Fig. 52). During its development some epidermal cells of the funiculus near the micropyle become conspicuous. Later, these divide periclinally to form a collar all round the funiculus (Figs. 52–56). The collar does not develop further till the stage of fertilization (Fig. 56). However, after fertilization, it shows pronounced development. It soon grows over the micropyle and completely encloses the seed (Figs. 57–60). In a longitudinal section the aril is about two to four layered at its tip and multilayered at the base (Figs. 58, 62). Its thin-walled cells are filled with plenty of oil, starchy material and yellow red chromoplasts. The persistent aril which is whitish to start with becomes brownish pink later. It completely envelops the brownish black seed, except at the chalazal end where it is open.

Discussion

While discussing the systematic position of the Cactaceæ (see Maheshwari, 1950, p. 364), the absence of division in the nucellar epidermis in the Passifloraceæ has been taken as one of the striking differences between these two families. However, in the present form, the nucellar epidermis divides periclinally adding a little to the mass of nucellar tissue.

The occurrence of persistent pollen tubes in the developing seeds has been reported in several angiosperms (Maheshwari and Johri, 1950; Venkata Rao, 1952). Venkata Rao (1952) attributes a haustorial function to such persisting pollen tubes in some Malvaceæ. According to him "the persistence without any collapse of the pollen tube with tough wall lined internally by a thin layer of cytoplasm and the presence of its rupture end at the base of the embryo are sufficient evidence to show the liaison behaviour of the persistent pollen tube conveying food material from the inner integument to the developing embryo". He also brings evidence of the crushed layers of the inner integument during the development of the seed. The persisting pollen tube of *Passiflora calcarata* has a fairly thick wall enclosing scanty cytoplasmic contents and does not get crushed by the adjacent tissues in the developing seeds. Though it shows the presence of cytoplasm there is no indication of its activity. So, it has no haustorial or liaison

function and a similar view has already been expressed by Maheshwari and Johri (1950).

The nuclear endosperm becomes cellular at a later stage. Dense aggregation of endosperm nuclei is seen in the chalazal region and also around the embryo. The chalazal endosperm tissue is distinguished from the rest by its larger cells and hypertrophied nuclei. Some of these cells are plurinucleate and show nuclear fusions. In the remaining endosperm, the cells along the periphery appear like meristematic cells, and those in the centre are vacuolate and hexagonal. The endosperm finally displaces the nucellus and its cells are filled with oily, starchy and proteinaceous contents.

The seed-coat of *Passiflora calcarata* is organised by the two integuments and in structure and development it recalls some of the features of *Adenia venenata*, *Passiflora holoserecea* and *P. hirsuta* (Netolitzky, 1926). In all these forms the number of layers in the outer and inner integuments is more or less the same. The seed-coat in *Adenia venenata* is peculiar in possessing lacunæ and there are no lignified layers in the inner integument at any stage of development (Netolitzky, 1926). But, in the species of *Passiflora* investigated so far, a lignified layer develops in the inner integument (Netolitzky, 1926). In *P. holoserecea*, the innermost layer of the inner integument gets crushed during the development of the seed-coat (Netolitzky, 1926). But, in *P. calcarata*, this layer, in particular, persists with brownish colouration. Further, in this form the cuticle develops echinulate thickenings; but, Netolitzky (1926) reports a simple cuticle for *P. holoserecea* and *P. hirsuta*.

In *Passiflora calcarata* the wedge-like ingrowths are developed from the seed-coat and are very prominent in the middle region of seed. They show a superficial resemblance to ruminations. A detailed account of these ruminations in a few Annonaceæ has been described by Corner (1949). According to him the ruminations are composed of foldings of inner integument into which extend portions of outer integument. But, in a few other cases, either the outer or the inner takes part in the organisation of ruminations. Development of such ruminations has also been recorded in a few other angiosperms (Voigt, 1888; Swamy, 1949; Sastri, 1954; Venkata Rao, 1955). The ingrowths of *Passiflora calcarata* become hardened by the deposition of lignin and a similar type of lignification is seen in some layers of cells in the ruminations of Annonaceæ (Corner, 1949). In Degeneriaceæ and Magnoliaceæ, however, the wedged-ruminations become stony due to the hardening of cell contents (Swamy, 1949). Dahlgren (1922) has described four types ruminations based on the correlation between the development of the nucellus, endosperm and seed. The ingrowths or the so-called ruminations of *Passiflora calcarata* correspond to the Spigelia type of Dahlgren, so far as the time of organisation of ingrowths is concerned. They are completely formed when the nucellus is still present and the endosperm is nuclear.

The aril in *Passiflora calcarata* arises from the funiculus in the form of a collar very near the micropyle, by the active division of a

group of epidermal and some hypodermal cells. It grows over th micropyle enveloping the seed, but remains open at the chalazal end

Summary

Developmental stages of microsporangium and male gametophyte, megasporangium and female gametophyte of *Passiflora calcarata* Mast. are described. Double fertilization has been observed. The endosperm is nuclear to start with but, later becomes cellular. Its structure and behaviour are described. The seed-coat is organised by both the integuments. The structure of seed-coat and formation of ingrowths are explained in detail. Aril development is followed.

I express my sincere gratitude to Professor P. Maheshwari, University of Delhi, Professor L. N. Rao, Doctors S. B. Kausik and K. N. Narayan, Central College, Bangalore, for their constant encouragement and valuable suggestions during this study. I am also thankful to Doctors M. A. Rau and K. Subramanyam, for correcting the manuscript and the Systematic Botanist, Coimbatore Herbarium, Coimbatore, for determining the species investigated here.

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1567-55 Printed at The Bangalore Press, Bangalore City, by C. Vasudeva Rao, Superintendent, and Published by Dr. T. S. Sadasivan, Business Manager, The Indian Botanical Society, University Botany Laboratory, Triplicane, Madras, 31-3-1956

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